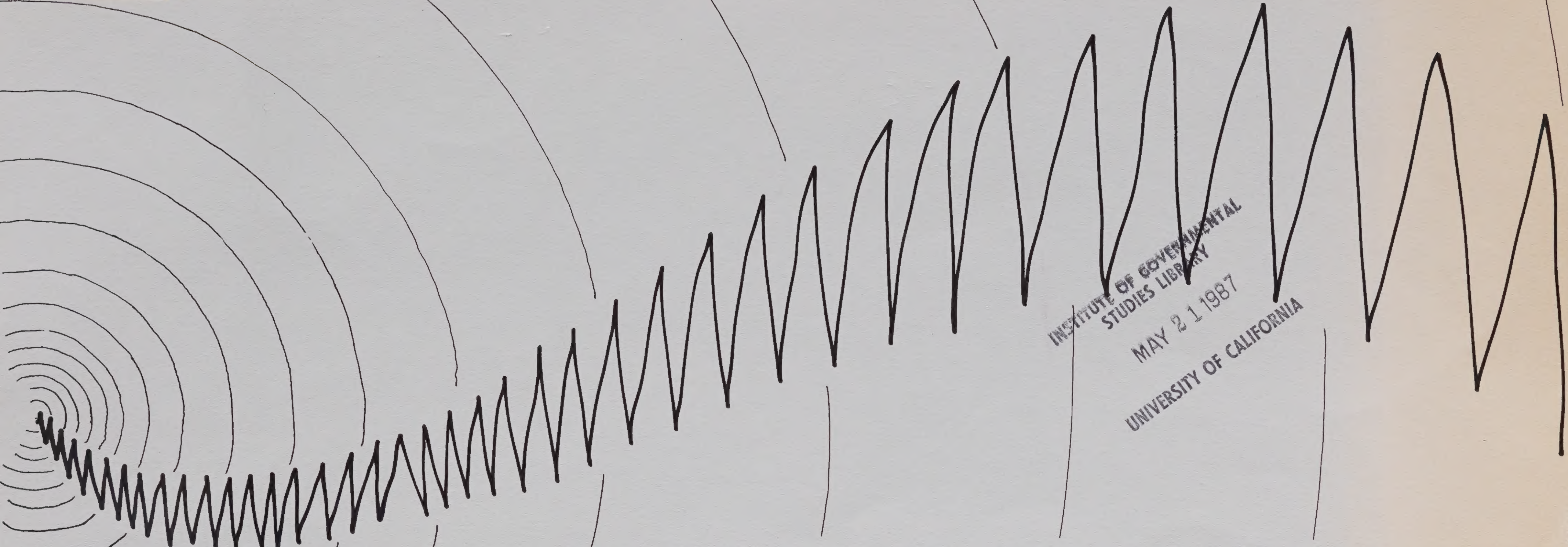
5/22/87



NOISE ELEMENT

city of san luis obispo

envicom

SEPTEMBER 1975

88 00648

CONTENTS

LIST OF FIGURES

LIST OF TABLES

PART 1: POLICY STATEMENT

I. INTRODUCTION

A. LEGISLATIVE AUTHORITY

In making city and county governments in California responsible for a Noise Element in their General Plans, the Legislature has recognized the steady escalation of outdoor noise as a significant environmental hazard. Unlike other hazards faced by California residents, such as earthquakes or floods, noise is generated primarily by man's own activities. Considering noise in the planning process, then, is essential to controlling its impact on the community. Specific authority for this Element of the General Plan is contained in Government Code Section 65302(g), which requires the following:

> (g) A noise element in quantitative, numerical terms, showing contours of present and projected noise levels associated with all existing and proposed major transportation elements. These include but are not limited to the following:
>
> (1) Highways and freeways,
> (2) Ground rapid transit systems,
> (3) Ground facilities associated with all airports operating under a permit from the State Department of Aeronautics.
>
> These noise contours may be expressed in any standard acoustical scale which includes both the magnitude of noise and frequency of its occurrence. The recommended scale is sound level A, as measured with the A-weighting network of a standard sound level meter, with corrections added for the time duration per event and the total number of events per 24-hour period.
>
> Noise contours shall be shown in minimum increments of five decibels and shall be continued down to 65 dB(A). For regions involving hospitals, rest homes, long-term medical or mental care, or outdoor recreational areas, the contours shall be continued down to 45 dB(A).
>
> Conclusions regarding appropriate site or route selection alternatives or noise impact upon compatible land uses shall be included in the General Plan.
>
> The state, local, or private agency responsible for the construction or maintenance of such transportation facilities shall provide to the local agency producing the general plan a statement of the present and projected noise levels of the facility, and any information which was used in the development of such levels.

B. PURPOSE AND APPROACH

As a mandated part of the General Plan, the Noise Element is intended to serve as the City's official guide in public and private development matters related to outdoor noise. The basic goal of the Element is to outline a comprehensive plan to achieve and maintain a noise environment that is compatible with a variety of human activities in different land uses. To achieve this goal, the Element provides a quantitative estimate of noise exposures, land use noise standards, and recommended policies for controlling noise in the City. This information is intended for use in conjunction with other adopted policies of the General Plan, particularly those of the Circulation, Land Use, and Housing

Elements.

This Interim Noise Element has been completed as a preliminary document for the City, to be followed by the complete Noise Element being prepared under the auspices of the San Luis Obispo Area Coordinating Council. The focus of this first document is on existing road and rail traffic generated noise only. Existing air traffic and stationary source noise, and future noise, will be considered in the forthcoming Noise Element, scheduled for completion in mid-December, 1975. This document has been prepared in accordance with the City's General Plan schedule under a contract separate from that with the Area Coordinating Council, of which the City is also a signatory.

This Interim Noise Element has been prepared as a single document for the City of San Luis Obispo in two component sections. The first, the Policy Statement, is concerned with the implications of the technical findings for the City, while the second, the Technical Analysis, addresses the nature and extent of noise exposure. The Noise Element is one of the more technical Elements of the General Plan. However, the approach of this report is to present the discussions of noise primarily in qualitative form and to rely on the use of figures in presenting certain mathematical concepts. Those wishing a more detailed technical explanation are referred to the works listed in the General References.

C. RELATIONSHIPS TO OTHER GENERAL PLAN ELEMENTS

The Noise Element is most closely related to the Circulation, Land Use, and Housing Elements. The principal noise sources evaluated in the Element are transportation noise sources; namely, roads, railroads, and airports. Noise generated by these sources depends primarily on the number and type of vehicles in operation as planned for in the Circulation Element.

Inseparable from the circulation considerations in the General Plan are the locations and types of land uses in the City. The locations of circulation routes in relation to different land uses can be a major determining factor of noise exposure. It is important that consideration be given in the Land Use Element to separating the most noise sensitive land uses from the sources of high noise levels. Land use noise standards are recommended as a part of this Element to assist in these considerations.

The Housing Element is related to the Noise Element in that both the location and insulation requirements of housing are, in part, determined by noise exposures.

II. EXISTING CONDITIONS

A. NOISE EXPOSURES

The existing noise levels in the City of San Luis Obispo generated by road and rail traffic are presented in graphic form on the Noise Contours Map and in tabular form in Appendix B. These noise levels are expressed in decibels in terms of Day-Night Noise Levels (abbreviated L_{dn}). Detailed explanations of L_{dn} noise levels and the methods used to estimate them are presented in the Technical Analysis. The following brief discussion is intended to provide a basic understanding of the terms to facilitate use of the Noise Contours Map.

Common noises experienced by each of us daily may range from a whisper to a locomotive train pass-by. The range of sound <u>energy</u> represented by these two events is so large that it cannot be represented mathematically without using numbers in the millions and billions. To avoid this inconvenience, sound levels have been compressed in a standard logarithmic scale called the decibel (dB) scale. The reference level for the scale, 0 dB, is not the absence of sound, but the weakest sound a person with very good hearing can detect in a quiet place. The most important feature of the decibel scale is its logarithmic nature. An increase from 0 to 10 dB represents a tenfold increase in sound energy, but an increase from 10 to 20 dB represents a hundred fold increase, and from 20 to 30 represents a thousand fold increase over 0 dB.

The average range of sounds that we are commonly exposed to generally fall in the 30 to 100 dB range. However, not all sound waves affect us equally. The human ear is more sensitive to high pitch sounds, such as a whistle, than to low pitch sounds, such as a drum. To account for this effect in noise measurements, it is necessary to use an electronic filter in sound level meters which acts as the equivalent of the human ear in filtering out some of the lower frequencies of sound. This filter is called the A-scale weighting network, and is abbreviated by the A in the notation dBA.

A-scale decibel measurements can be taken at any time in the community to record the sound levels of various noise sources. However, to develop an indicator of varying sound levels occuring over the 24-hour day, it is necessary to average the sound occuring at each moment throughout the day. The Day-Night Noise Level is the result of this procedure, and gives a general, single-number index of noise exposure over an average 24-hour day. In computing the L_{dn} levels, it is also necessary to apply a weighting to noise that occurs at night to account for the greater sensitivity of people to noise at night. L_{dn} noise levels can be developed for road traffic, as well as rail and air traffic for which the measure has

been used traditionally. As examples of typical L_{dn} noise level ranges, Figure 1-1 gives ranges of L_{dn} decibel exposures ranging from quiet rural areas to an area under the flight path of a major airport.

The current noise environment of San Luis Obispo is composed of sounds from many sources. Road and rail traffic as analyzed in this report represent two of the most significant sources in terms of both noise magnitude and the size of the area exposed to noise. Summary conclusions from the Technical Analysis are:

1. Of road and rail traffic noise, US 101 is the most significant source of noise in San Luis Obispo.

2. The Southern Pacific Railroad line is second only to US 101 in significance as a source of environmental noise.

3. The following major streets also generate relatively high noise levels along most or all of their lengths: Santa Rosa Street, Foothill Boulevard, Madonna Road, Monterey Street, and Johnson Avenue.

4. Noise levels close to these major sources exceed the recommended land use noise standards for certain areas. Sites identified as potential problem areas include the French Hospital, County Hospital, Laguna Lake Park site, Sinsheimer Park, and the San Luis Obispo Senior and Junior High schools. Further site analysis is needed to define the extent of these noise problems, if any are confirmed to exist.

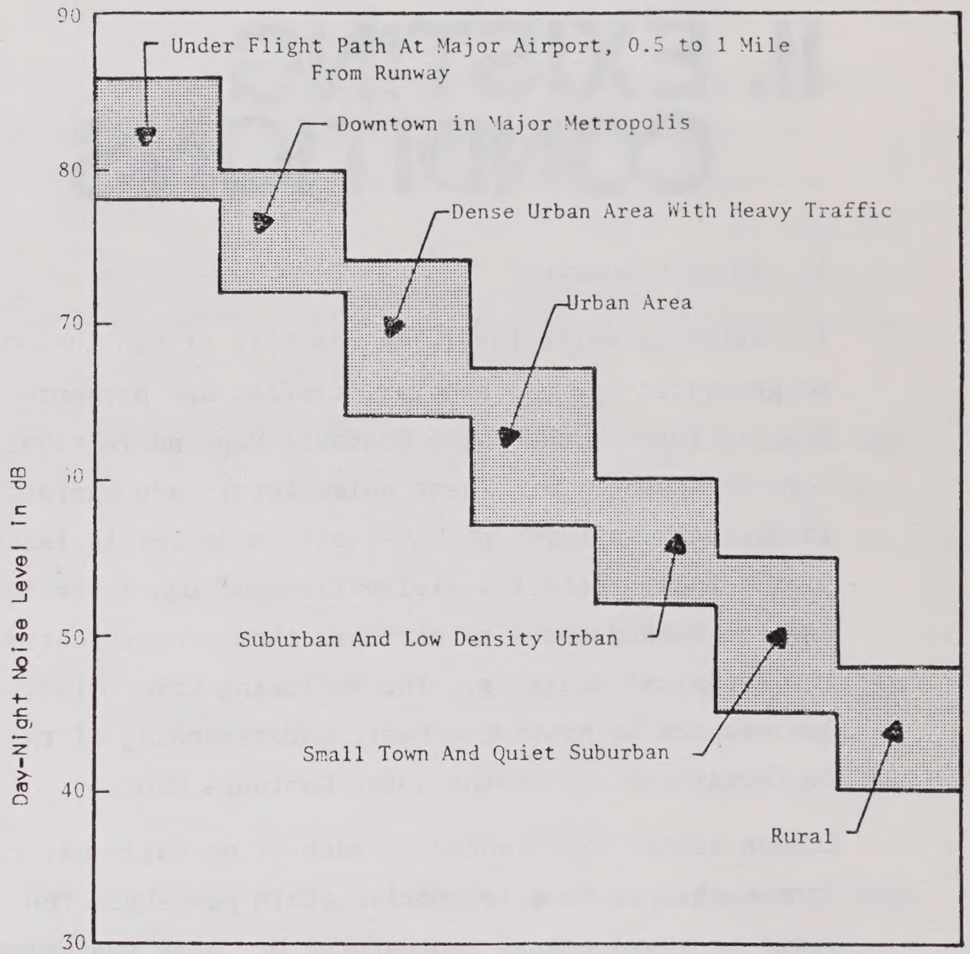


FIGURE 1-1

TYPICAL L_{dn} NOISE LEVEL RANGES

(Source: Bolt, Beranek, and Newman, Inc., 1974)

B. EFFECTS OF NOISE

1. General

Noise affects man and his environment in a number of important ways. Some sounds cannot be heard or are not noticed, yet the human body reacts involuntarily to them. Other sounds are intense and quick enough to rupture the eardrum. However, all sound is not destructive. The point should be emphasized that sound is vital to communication and necessary for the maintenance of life.

As sound levels increase, they quickly reach levels which are detrimental to health and well-being. The effects of noise may be thought of as falling into four categories: physical, psychological, social, and economic. The lines between the categories are not established; there is much overlap. As research in acoustics and human response to sound progresses, the effects of noise will be more completely defined. This discussion is intended to be a brief summary of existing knowledge.

2. Physical

The most serious physical effect of noise is damage to hearing, and the most tragic damage to hearing is a permanent shift in the hearing threshold (termed permanent threshold shift or PTS). Once the cells of the inner ear are ruptured or otherwise damaged, there is no known way to repair them. The cells do not regenerate. To persons intermittently exposed to high noise levels, the hearing threshold may be shifted temporarily (termed temporary threshold shift or TTS). Most of us have experienced TTS at sometime, for example, when a firecracker explodes or a loud, sharp noise occurs nearby. For awhile, we cannot hear sounds at lower intensities. While the ear eventually recovers from this kind of damage, TTS can be a significant problem to persons exposed to noise frequently. Besides the physical effect of noise on our hearing, a number of other physiological reactions occur in a noisy environment. Noise is one of the principal urban stresses experienced daily by city dwellers. The body interprets noise as a form of stress and reacts accordingly. Most of the responses are automatically produced by the involuntary nervous system. The individual may not be consciously aware that his body is under stress, and that nervous reactions are occurring. Furthermore, the individual may not be aware that noise is the source of stress even if he was aware of the stress in the first place. Reactions to noise are similar to reactions to intense emotional states such as fear or anger. Some of the responses are (1) an increase in blood pressure, (2) an increase in heart rate, (3) dilation of the pupils, (4) increase in blood cholesterol, (5) increase in hormone levels by endocrine glands, (6) change in the rate of acid secretion by the stomach, (7) increase in sweat gland activity, and (8) increase

in respiration. These responses lead to increases in heart disease, ulcers, tension, hypertension, and allergic reactions. It has been documented that noise affects us even in the womb before birth. Even relatively low levels of noise in the mother's environment can cause the fetus' heart rate to increase significantly. Other research concludes that very loud noises can possibly be as much a cause of congential malformations as thalidomide or German measles. On a less serious level, noise is responsible for many headaches and much daily fatigue in urban areas. Noise may affect our health adversely only if we are exposed to high levels for long periods of time, but it can impair our well-being through the kind of effects listed above at levels commonly experienced in urban areas.

The effects of noise discussed above are produced by sounds in the audible frequency range. Mention must also be made of two categories of sound which cannot be heard - "ultrasonics" and "infrasonics". Ultrasonics refers to the range of sounds above 20,000 Hertz or wave cycles per second, the upper limit of human hearing. A dog whistle is a common example of a device which produces ultrasonic frequencies. Infrasonics, on the other hand, refers to frequencies below the audible range, that is, below 20 Hertz.

For years, ultrasound has been used in medicine to treat asthma, cycstic fibrosis, and other respiratory ailments, and in a variety of ways to clean small instruments, jewelry, tools, dentures, etc. Useful and common as ultrasound is, it is known to be hazardous if improperly applied. It specifically should not be directed at areas of poor blood circulation or cancerous infection. The presence of ultrasound in the ambient urban atmosphere is generally insignificant compared to audible frequencies, but it should be noted as a potential health hazard.

Infrasound is less familiar to most people, and research into the world of infrasonics is relatively recent. These low frequency pressure waves seem mostly to act on the internal organs - the heart, lungs, and viscera - by vibrating them. The organs are rubbed together by a kind of resonance creating dizziness, nervous fatigue, and seasickness. A frequency of 7 Hz. has been found to be fatal at high enough intensities. Infrasound has been measured in the everyday ambient atmosphere in Washington D.C. Some of the sources were identified as large scale natural events such as tornadoes in Oklahoma, an earthquake in Montana, and magnetic storms in the upper atmosphere. A large number of sources remain unidentified, however. One common source of infrasound is a large industrial ventilation system. More so than ultrasound, infrasound can be considered part of the urban environment and affects us daily.

Noise affects animal behavior in ways similar to human behavior. Little research has been done in this field,

especially on wild animals, but there are strong indications that unfamiliar noises can disrupt population dynamics and individual growth behavior. A single startle can stop the brooding cycle of wild game birds. Continuous noise can mask predator-prey signals inducing huddling, panic, or migration. Animal ears are subject to similar kinds of physical damage as human ears. Loss of hearing because of noise exposure has been documented in a number of laboratory cases with a variety of species. Animals also react to noise as stress which produces neural and hormonal changes affecting urinary, adrenal, and reproductive functions.

In the wild, these effects can significantly alter the "natural balance" between various species and between species and their environment. An animal which depends on hearing to locate prey could starve if its auditory function was impaired. Mating signals could be interfered with, and distress signals may be masked by background noise. All of these effects can lead to increased mortality rates.

Domestic animals may suffer more since they are usually closer to urban areas. Farm animal productivity may be diminished, and mortality rates can be increased as well. The economic impact of these effects would make further study in this area worthwhile. The point to be made is that noise impacts the animal population in the City of San Luis Obispo, as well as the human population.

Noise also effects the non-living physical environment in the City. The example of high pitched sound resonating and shattering glass is common. Structural damage by noise is usually moderate, however, even in sonic booms. Glass and plastic are generally the materials most susceptible to damage by noise. Others include base coats of paint, finish coats, stucco, wallboards, interior tiles, brick, concrete blocks, and organic adhesives. Temporary vibrations may be induced in various kinds of structures, particularly buildings, by noise as well. Structural response to sound is highly variable, however, and most damage is usually concentrated in secondary structures such as glass or plaster.

It is important to ask whether any of these physical or physiological effects are occuring specifically in the City of San Luis Obispo. A study of these effects has not been conducted as a part of the Noise Element program, so it is difficult to give a precise answer. Health and welfare criteria have been publisehd by the federal Environmental Protection Agency, however, and these criteria are part of the basis of the recommended land use noise standards. By comparing these criteria to the road and rail traffic noise levels in San Luis Obispo, some general conclusions can be drawn.

The basic criteria are given in Table 1-1, and utilize Sound Equivalent Level (L_{eq}) and L_{dn} noise levels. The L_{eq} is the basis for the L_{dn} noise level, but does not include a weighting for nighttime noise. It should also be

Table 1-1

SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

(Source: US Environmental Protection Agency, 1974)

EFFECT	LEVEL	AREA
Hearing Loss	$L_{eq(24)} \leq 70$ dB	All areas
Outdoor activity interference and annoyance	$L_{dn} \leq 55$ dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq(24)} \leq 55$ dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas.
	$L_{eq(24)} \leq 45$ dB	Other indoor areas with human activities such schools, etc.

noted an "adequate margin of safety" has been built into the criteria. Judging by these criteria, and the Noise Contours Map, most of San Luis Obispo is free from excessive noise. However, certain areas, primarily those near the roads and the railroad, (as listed in the summary technical conclusions) are exposed to noise levels which could result in activity interference and stress. It is unlikely that any resident's hearing is threatened unless they are spending a long period of time in close proximity to the freeway.

3. Psychological

It is difficult to distinguish between physical and psychological effects of noise. Many of the behavioral responses to noise are rooted in the involuntary physiological reactions. The two most serious psychological effects of noise are interference with sleep and speech. Data on interference with sleep shows that this response is more subjective than interference with speech, but generally noise levels will interrupt or impair sleep in the 40 to 45 dBa range. Noise acts on the body when it is asleep in the same manner as it does when the person is awake. The ear does not mask noise during sleep. Even if noise levels do not awaken a person, they can interfere with dream stages shifting a person from a deeper dream stage to a shallower one. Any disruption of deep stage dreaming is thought to impair mental health and well-being. Loss of sleep is known to impair a per-

son's ability to carry on normal daily tasks, especially those requiring short term memory or high speed processing of information. Severe deprivation of sleep can create irascibility and mental disorganization causing dreaming while awake, hallucinations, and other behavior bordering on temporary mental illness. It is important to remember that noise can disturb the rest of sleeping persons whether they awaken or are aware of the noise or not.

Interference with speech depends, of course, on how far the people are from each other, the level of their voices and other parameters. The understandable reception of voice sounds in ordinary conversation is usually interfered with at the level of 50 to 60 dBA. The social costs of interference with speech can be of great magnitude and are discussed below. The behaviorial impacts of speech interference include impairment of leisure activities needed for stable human behavior, and irritability when conversations must stop until the noise decreases. Noise also interferes with concentration and the ability to perform tasks.

While it has never been proven that exposure to noise alone can cause mental illness or breakdown, it is true that exposing a depressed individual to noise doesn't help. A famous English study reported in 1969 that individuals closely exposed to the noise of London's Heathrow Airport had higher admission rates to mental hospitals than people living farther from the noise. Such evidence is not entirely convincing, but does warrant further investigation. It is a good indication that noise, as an additional form of unwanted stress, can provide the increment to bring on emotional crises.

4. Social

The reactions of groups and communities to noise are similar to the reactions of individuals. It is clear that noise interferes with social processes. Its foremost effect is to disrupt the ability of people to communicate with one another. Communication by sound is vital to almost all human social behavior, and its impairment should not be underestimated. As an important example, consider educational processes. Children who attend school near sources of loud noise can have their learning and socialization processes severely handicapped. Several schools in Westchester were forced to close down because the noise near the Los Angeles International Airport interfered so seriously with teaching. The effects of noise on other social processes such as marketing, recreation, and the practice of religion are equally as serious.

5. Economic

One of the more prevalent economic effects of noise of concern to San Luis Obispo is the reduction of residential property values near the source of noise. This

document does not examine specific property values in the City, but a comparison of residential property values near the railroad tracks or the freeway with residential property located away from these sources may bear this out.

One other kind of major economic cost of noise is noise-induced inefficiency in the labor force. As noted under psychological effects, noise interferes with the performance of tasks. Such interference causes business and industry to lose income through lost output. At the national level, such losses total millions of dollars daily. Occupational noise yearly results in hundreds of millions of dollars of compensation claims, and the costs of insulating environments and muffling sources should be included as economic costs as well. Economic costs of noise are among the most difficult to calculate, however, because they are associated with the psychological states of stress discussed above. The effects of these states have yet to be adequately quantified by economists.

C. NOISE REGULATIONS

Heightened concern in recent years for "environmental quality" has led to greater attention by the legislative and administrative branches of government to the problem of excessive noise. This attention has resulted in the enactment of a number of laws and regulations regarding noise. Unfortunately, there has been little coordination among the agencies resulting in the use of different noise evaluation techniques and standards in these regulations. This non-uniform approach makes comparison and use of standards and regulations a confusing matter for both the general public and those government officials responsible for compliance at the local level. Table 1-2 provides a summary list of existing noise regulations which pertain to the City of San Luis Obispo. In addition to those laws shown in the table, both the National Environmental Protection Act (NEPA) and the California Environmental Quality Act (CEQA) require environmental analysis of certain developments including an analysis of potential noise problems at the project site.

The most significant of the laws listed in Table 1-2 is the Noise Control Act of 1972. This law essentially authorizes the EPA to coordinate noise regulation at the national level. It also authorizes the EPA to set noise emission limits for major noise sources including aircraft, motor vehicles, and trains. These emission standards can be expected to have an important effect on future noise levels in the City. In addition, health and welfare criteria for noise exposure limits have been published in compliance with the Act, and these criteria have been incorporated into the recommended land use compatibility standards. In publishing

TABLE 1-2

EXISTING FEDERAL AND STATE NOISE REGULATIONS

	Responsible Agency	Regulation/Standard	Noise Source Regulated	Summary
FEDERAL	Environmental Pro- Agency	Public Law 92-574 (Noise Control Act of 1972)	All	Gives EPA responsibility to identify noise sources, set standards for limiting emissions, publish health and welfare criteria, set product labeling standards, and recommend aircraft standards.
	Federal Aviation Administration	FAR Part 36	Aircraft	Sets emission limits for aircraft under specified flight conditions for type certification.
	Federal Highway Administration	PPM 90-2	Highways, outdoor noise environment	Sets land use compatibility requirements for developments adjacent to Federal-aid highways.
	Department of Housing and Urban Development	Policy Circular 1390.2	Airports, outdoor noise environments	Sets noise acceptability requirements for developments requesting Federal loan assistance.
STATE OF CALIFORNIA	Department of Aeronautics (Caltrans)	California Administrative Code, Title 4, Sub-chapter 6	Airports, Aircraft	Specifies maximum noise exposures for sensitive uses near airports; sets standards for aircraft operations.
	Department of Motor Vehicles	California Vehicle Code Section 23130	Motor Vehicles	Sets noise emission limits for motor vehicles under specified operating conditions.
	Department of Transportation (Caltrans)	Streets and Highways Code	Highways	Requires corrective action when noise levels exceed set limits in nearby schools.

TABLE 1-2

(Continued)

	Responsible Agency	Regulation/Standard	Noise Source Regulated	Summary
STATE OF CALIFORNIA	Commission of Housing and Community Development	California Administrative Code, Title 25, Article 4	Outdoor/Indoor noise environments	Limits interior noise levels resulting from outdoor levels in new multi-family units.
	Council on Intergovernmental Relations	California Government Code, Section 65302(g)	Outdoor noise environment	Requires quantitative Noise Elements in all City and County General Plans.

these criteria, the EPA has selected and recommended the L_{dn} measurement scale for use as a uniform noise evaluation scheme. If nationwide use of this measure becomes a reality, much of the existing confusion regarding noise should diminish. This should enable the City to enact noise control regulations and measures consistent with those of the County and neighboring communities, as well as the State and Federal government.

III. NOISE CONTROL

A. ALTERNATIVE NOISE CONTROL STRATEGIES

Any action to control noise will work on either the source of the noise, its transmission path, the receiver of the noise, or any combination of these facets of sound. As noted in the preceding section, source controls are primarily the responsibility of the federal government, and to a lesser degree, the state government. Control of the reception of noise, however, has its roots in local government's traditional authority over land use control.

The basic goal of this Element is to achieve and maintain a noise environment that is compatible with a variety of human activities. This clearly calls for cooperation among all levels of government. Source controls are the most effective means of reducing noise, but there are limits to what can be accomplished through technology alone. A need for land use controls, coupled with source controls, will be probably be necessary for overall noise reduction in many cities for the forseeable future.

The purpose of this section of the Noise Element is to outline some of the land use and other types of noise reduction alternatives that are available for implementation by the City. These various strategies form the basic planning framework for the recommended goals and policies of the next sections.

Generally, noise control strategies may be thought of as belonging to one of three approaches. From least restrictive to most restrictive, these strategies are: (1) to encourage voluntary noise reduction measures by property owners and developers, (2) require noise reduction or compatible land use through zoning and planning powers, and (3) enact noise control through City ownership of the affected property.

The first approach would include providing information to builders and the general public regarding the importance of noise reduction and different construction and site development techniques for noise compatibility. Various means of achieving this objective include review of proposals by an architectural review board, design services by City staff during the permit application process, and maintenance of an acoustical information library for developers and the public. Education of the public is an important aspect of this approach since public awareness of noise problems can affect the marketability of developments. Such an approach can be successful in solving noise problems provided there is a degree of cooperation between the local government and developers or if the development market is a buyer's market and there is a demand for noise compatibility.

If these conditions do not exist, it may be necessary to use the City's police powers of zoning and planning to ensure that the public is protected from excessive noise. These measures can be an important influence on future development, but may be of little help in resolving existing noise problems. The basic approach is the exclusion of noise sensitive land uses from areas of high noise levels. If development is permitted in noise-impacted areas, zoning performance and development standards can regulate the details of the development such as building height, buffer areas, and noise barrier construction. Special types of development, such as cluster housing and planned unit developments, can be regulated to prevent unnecessary noise problems from occurring. Building codes may be enforced under this approach as well to limit the transmission of sound into and out of buildings. One concept being implemented in a number of cities in California and across the US is the adoption and enforcement of a noise ordinance which sets quantitative limits on the level of noise permitted in different zones in the City.

Short of purchasing land, the City can also use tax incentives to regulate land development to a certain degree. This is a potentially powerful land use control which can reduce development pressure on vacant land. The basic technique is to reduce the assessed value of land in noise impacted areas so that landowners are not pressured into selling land they can no longer afford to pay taxes on. This approach has been used in California to preserve open agricultural land under the Williamson Act with varying degrees of success.

City ownership of noise-impacted land makes the regulation of its use a simpler matter, but the acquisition of the property can be expensive and unpopular locally if eminent domain is used. Purchase or the use of eminent domain powers can be avoided through purchase of an easement regulating the land without transfer of ownership.

Which of these three approaches is used depends in large measure on the severity of the noise problem. The Technical Analysis of this Element concludes that, for the most part, the City of San Luis Obispo is free from excessive noise levels from rail and road traffic except in close proximity to certain major sources such as US 101 and the Southern Pacific railroad tracks. It is unlikely, then, that the City needs to consider the most restrictive approach, and can rely on zoning and planning to prevent major noise problems from occurring near these sources.

All of the above strategies deal primarily with reducing future noise problems rather than existing ones. Where a noise problem already exists, one or more of five solutions are available: (1) the noise can be reduced

at the source, (2) the noise can be blocked by an insulating barrier, (3) the source can be removed from people and other receivers, (4) the receiver can be removed from the source, or (5) the time exposure to the noise can be minimized. As is true with most environmental hazards, preventing or reducing the cost of the future hazard is easier and less expensive than resolving existing problems. Special ordinances can be adopted, however, which set noise limits by land use zones, and which require compliance by existing developments. One of the central problems of setting noise limits by zone is the number of desirable exceptions to the established noise limit.

B. RECOMMENDED GOAL

Consistent planning for a noise environment that is compatible with the health and well-being of the residents of San Luis Obispo requires that goals be set and adhered to. Goals address general policy directions and form the basis for planning decisions and actions. The basic goal recommended for noise control in San Luis Obispo is:

> To ensure that the City of San Luis Obispo is free from excessive noise and abusive sounds.

In defining this goal, primary emphasis should be placed on protecting the general public from noise levels which may be hazardous to hearing. Second in importance is the minimization of noise induced stress, annoyance, and activity interference.

C. RECOMMENDED POLICIES

The following recommended policies complement the planning goals and define specific directions for the City to take in ensuring a compatible noise environment.

1.0 Establish land use noise compatibility standards for general planning and zoning purposes.

2.0 Provide for the identification and evaluation of potential noise problem areas.

3.0 Reduce existing and potential incompatible noise levels in problem areas through land use strategies, building and subdivision code enforcement, and other administrative means.

4.0 Provide for the education of the community in the nature and extent of noise problems in the City.

5.0 Coordinate noise control activities with those of other responsible jurisdictions.

6.0 Provide for periodic review and revision of the Noise Element.

D. IMPLEMENTATION

The implementation recommendations of this section provide the City with a series of specific actions for carrying

out the recommended policies of the preceding section. While it would be desirable to fully implement each of the recommended actions, it is recognized that unlimited resources to that end are not available. To aid in determining priorities for the allocation of resources in the community, the recommended actions are listed below in their general order of importance to achieving the goal of the Element.

1.0 Establish land use noise compatibility standards for general planning and zoning purposes

1.1 Adopt the noise compatibility standards providedin Figure 1-2 for use in identifying potential noise problem areas, and in reviewing environmental impact documents.

1.2 Develop a zoning ordinance setting specific noise limits for various land uses.

2.0 Provide for the identification and evaluation of potential noise problem areas

2.1 Using the noise compatibility standards provided in Figure 2-1, review existing land uses to identify potential noise problems.

2.2 Provide for site analysis of potential noise problem areas.

2.3 Establish an on-going noise monitoring program to identify and evaluate noise levels in the City.

3.0 Reduce existing and potential incompatible noise levels in problem areas through land use strategies, building and subdivision code enforcement, and other administrative means

3.1 Discourage development of noise sensitive uses in incompatible noise-impacted areas close to major noise sources.

3.2 Strictly enforce all existing noise control regulations, including building and subdivision laws.

3.3 In existing or future development in noise-impacted areas, encourage or require through ordinance that proper site planning and insulation measures are taken to reduce noise to the established levels.

4.0 Provide for the education of the community in the nature and extent of noise problems in the City.

4.1 Develop an information release program to familiarize residents of San Luis Obispo with the Noise Element and noise problems in general. Special attention should be paid to identifying and informing those people now residing or working in noise problem areas.

4.2 Provide developers and builders with specific design information to reduce noise levels in new and existing developments. Consult with developers during the permit application process regarding potential noise problems.

Figure 1-2

LAND USE COMPATIBILITY GUIDELINES

LAND USE CATEGORY	Maximum Interior Exposure, L_{dn}*
Residential - Single Family, Duplex, Mobile Homes	45
Residential - Multiple Family, Dormitories, etc.	45
Transient Lodging	45
School Classrooms, Libraries, Churches	45
Hospitals, Nursing Homes	45
Auditoriums, Concert Halls, Music Shells	35
Sports Arenas, Outdoor Spectator Sports	
Playgrounds, Neighborhood Parks	
Golf Courses, Riding Stables, Water Rec., Cemeteries	
Office Buildings, Personal, Business and Professional	50
Commercial - Retail, Movie Theaters, Restaurants	50
Commercial - Wholesale, Some Retail, Ind., Mfg., Util.	
Manufacturing, Communications (Noise Sensitive)	
Livestock Farming, Animal Breeding	
Agriculture (except Livestock), Mining, Fishing	
Public Right-of-Way	
Extensive Natural Recreation Areas	

*Due to exterior sources (Source: Bolt, Beranek, and Newman, Inc., 1974)

EXPLANATION

FOR

FIGURE 1-2

CLEARLY ACCEPTABLE:

The noise exposure is such that the activities associated with the land use may be carried out with essentially no interference.
(Residential areas: both indoor and outdoor noise environments are pleasant.)

NORMALLY ACCEPTABLE:

The noise exposure is great enough to be of some concern, but common building constructions will make the indoor environment acceptable, even for sleeping quarters.
(Residential areas: the outdoor environment will be reasonably pleasant for recreation and play at the quiet end and will be tolerable at the noisy end.)

NORMALLY UNACCEPTABLE:

The noise exposure is significantly more severe so that unusual and costly building constructions are necessary to ensure adequate performance of activities.
(Residential areas: barriers must be erected between the site and prominent noise sources to make the outdoor environment tolerable.)

CLEARLY UNACCEPTABLE:

The noise exposure at the site is so severe that construction costs to make the indoor environment acceptable for performance of activities would be prohibitive.
(Residential areas: the outdoor environment would be intolerable for normal residential use.)

4.3 Maintain a noise information library for both the general public and those with technical backgrounds involved in noise control.

5.0 Coordinate noise control activities with those of other responsible jurisdictions

5.1 Encourage the State Department of Transportation (CALTRANS) and the County Engineer to incorporate noise reduction methods in new and existing road construction.

5.2 Encourage the Southern Pacific Transportation Company to control its operations to reduce noise impacts on the community.

5.3 Coordinate noise monitoring activities with those now being conducted by the County Engineer.

5.4 Encourage the development and use of a uniform noise evaluation scheme at all levels of government.

6.0 Provide for periodic review and revision of the Noise Element

6.1 The Noise Element should be reviewed at least every two years and should be comprehensively revised every five years or whenever major changes in the noise environment occur.

6.2 Upon adoption of the Noise Element, a review committee should be established to oversee its implementation and to report to the City Council on implementation progress. This committee should be composed of representatives from the Department of Community Development, the City Engineer's Office, and the general public.

PART 2: TECHNICAL ANALYSIS

PREFACE

This part of the Noise Element has been prepared to provide the necessary technical back-up for the recommendations of the Policy Statement. The technical nature of some of the information contained in this section necessitates a scientific discussion. However, because of the diverse audience of the Noise Element, the approach has been to minimize the use of detailed mathematical presentations and scientific terminology. Rather, this section relies, for the most part, on qualitative descriptions of methodology and noise exposure. Those wishing a more detailed discussion of noise evaluation techniques are referred to those works in the General References list.

I. INTRODUCTION TO NOISE

A. SOUND MECHANICS

Fundamental to any discussion of environmental noise is an understanding of sound phenomena. Such an understanding is interdisciplinary in that the generation of sound waves is within the traditional domain of physics while the perception of sound is primarily a concern of physiology and psychology. In this section, the emphasis is on the source of sound waves. The next section deals with the reception of sound, and is followed by a discussion of sounds that are defined as noise in this Element.

Sound can be defined as a mechanical form of radiant energy which is transmitted by longitudnal pressure waves in air or another medium. To illustrate this definition, consider a tuning fork in vibration after being struck. As a tong of the fork moves in one direction, it compresses the air particles in its path producing an area of <u>condensation</u>. As the tong reverses direction, the air particles left in its wake spread out resulting in an area of <u>rarefaction</u>. This movement of air particles is a form of wave motion in which the displacements are <u>along</u> the direction of the wave motion and is termed <u>longitudinal</u> wave motion. This is in contrast to <u>transverse</u> waves, such as those in a vibrating string, in which the displacements are perpendicular to direction of wave motion.

Sound waves emitted by a source have two major dimensions: <u>frequency</u> (or pitch) and <u>amplitude</u> (or intensity). Frequency is measured by the number of sound waves passing a point in one second. This measure is termed "cycles per second" or "Hertz" (abbreviated Hz). In general, humans can hear sounds with frequencies from about 20 to 15,000 Hz, although those limits may be decreased or increased somewhat depending on the individual and the intensity of the sound. Sound waves below 20 Hz are in the realm of <u>infrasonics</u>, and cannot be heard. <u>Ultrasonics</u> refers to sound waves above 15,000 H_z which generally cannot be detected by the human ear either.

Amplitude is a measure of the height or depth of sound waves above and below a median line on a diagram of a sound wave (Figure 2-1). It is the intensity or magnitude of the sound, and is measured in decibels (abbreviated dB). The decibel system is a relative logarithmic scale of sound pressure which is based on human hearing. The scale has a number of important features. Its basic reference point is the weakest sound which a person with very good hearing can detect in a quiet place. This quantity of sound is assigned the value of 0 dB. Since the range of sound pressure which the ear can detect is

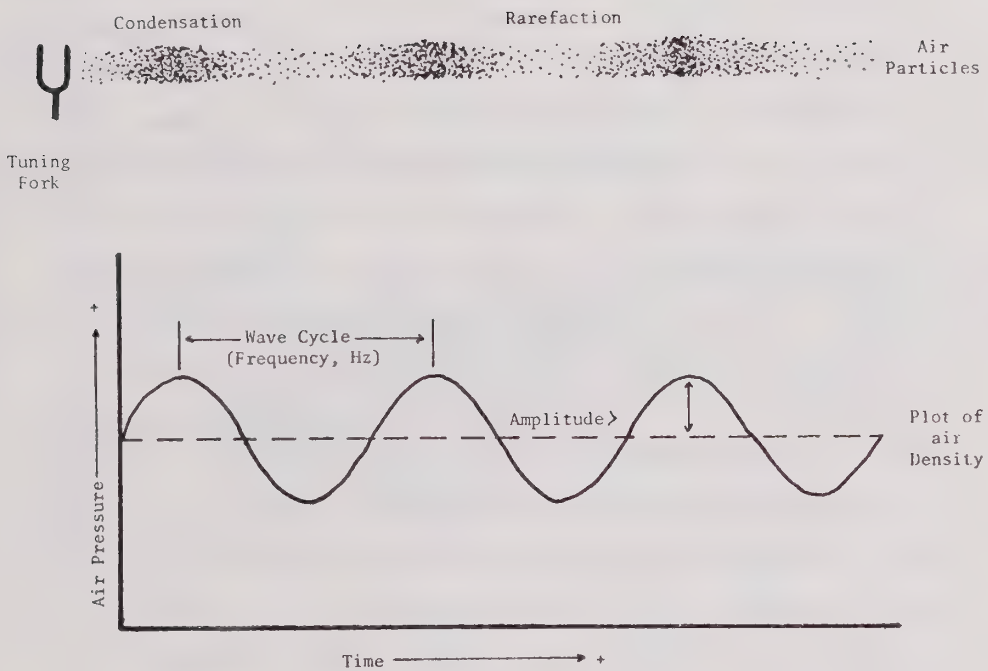


Figure 2-1. Diagram of Simple Sound Waves

so great, it is necessary to mathematically compress that range on a logarithmic scale of 0 to about 180. The most important aspect of this scale is that it does not progress arithmetically or linearly. That is, while a 10dB sound is 10 times as intense as a 0dB sound, 20dB is 100 times as intense as 0dB (rather than 20 times), and 30dB is 1000 times as intense as 0dB (rather than 30 times).

Another important feature of the decibel scale is that sound levels are not directly combined when they are added. For example, if one truck emits 65dB while idling, parking another truck producing 65dB next to it does not generate a total noise level of 130dB. Rather, the total noise level would be 68dB. The basis of this is the logarithmic nature of the decibel scale, and it is an important feature to remember when considering an area exposed to more than one source of noise. A convenient graphic method for combining decibels is provided in Figure 2-2.

B. HEARING

"If a tree falls in the woods and no one hears it, is there a sound?" This is an old question, and it serves to emphasize the three major facets of sound: generation, transmission, and perception. The following gives a brief description of the perception of sound, or what happens when someone hears the tree fall.

Example: Add 50 and 56 dB. Since the difference between the two levels is 6, locate 6 on the vertical axis. Read right to the curve and read down to 1. Add 1 dB to the higher level, 56, to yield the answer, 57 dB.

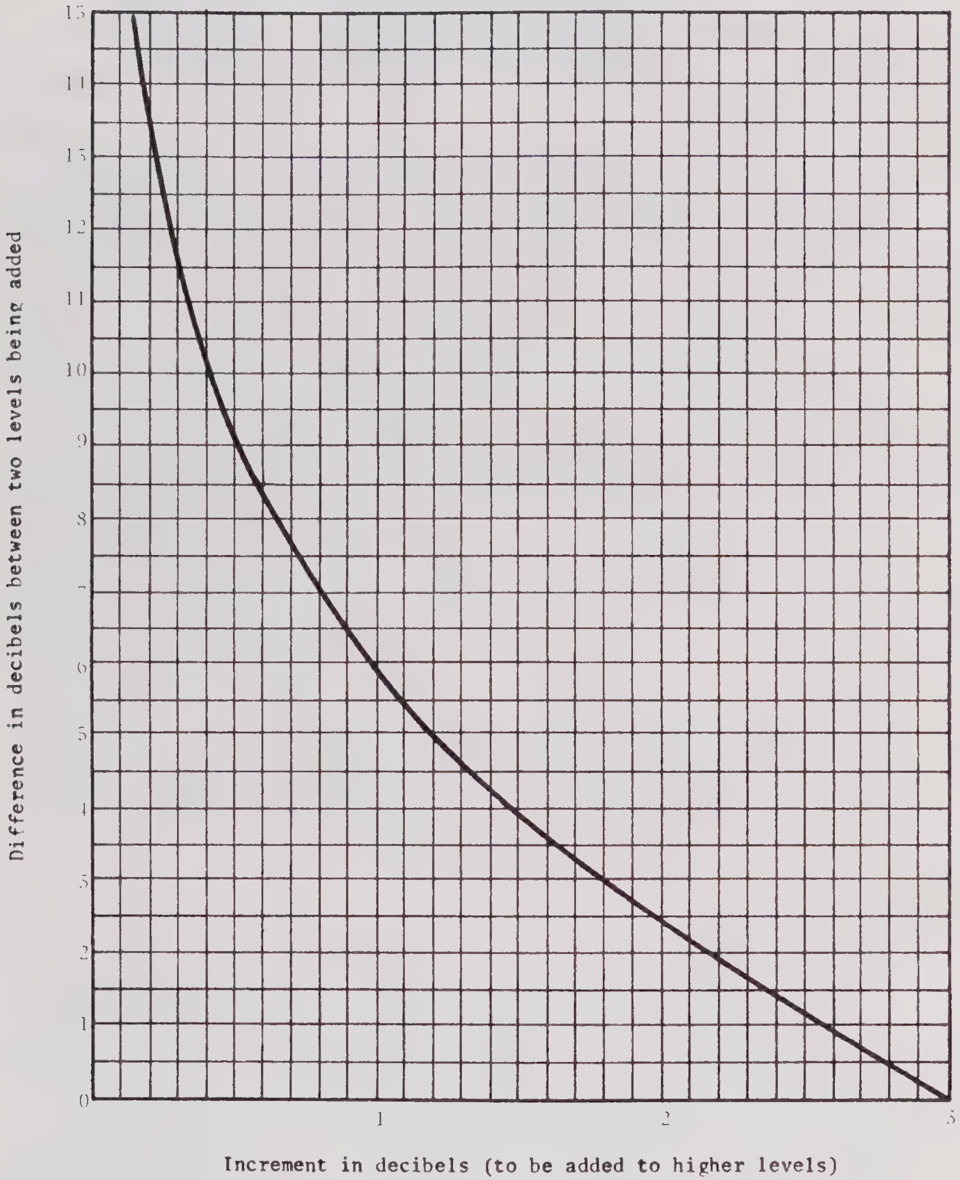


Figure 2-2. Chart for combining sound levels by "decibel addition".

The ability to hear involves a highly complex process and mechanism. The diagram in Figure 2-3 is a simplified picture of the ear which illustrates its three major parts: the outer, middle, and inner ear. The outer ear may be thought of as an air-filled funnel ending in a membrane, the eardrum. Sound waves travel down the funnel and impinge on the eardrum causing it to vibrate. This vibration mechanically transmits the sound wave to the middle ear which consists of a set of three connected bones. These small bones act as levers to amplify the vibrations on the ear drum, and to distinguish sound waves from the eardrum from those coming through other head tissues and bones. This part of the ear ends in a sound membrane called the oval window which separates the air-filled middle ear from the liquid-filled inner ear or cochlea. The window transmits the mechanical vibrations into liquid waves which travel through the spiral, parallel tubes of the cochlea. A basilar membrane separates two of these tubes; and, as it is distorted by the liquid waves, hair-like cells (cilia) are bent and trigger nerve cell endings by mechanical, chemical and electrical processes. These signals are transmitted to the brain through the auditory nerve.

It is interesting to note that the ear is sensitive to a wide range of acoustic stimuli, but has not evolved involuntary response mechanisms to protect it from very loud noises without temporary or permanent loss of hearing acuity. This contrasts with the eye, which has evolved

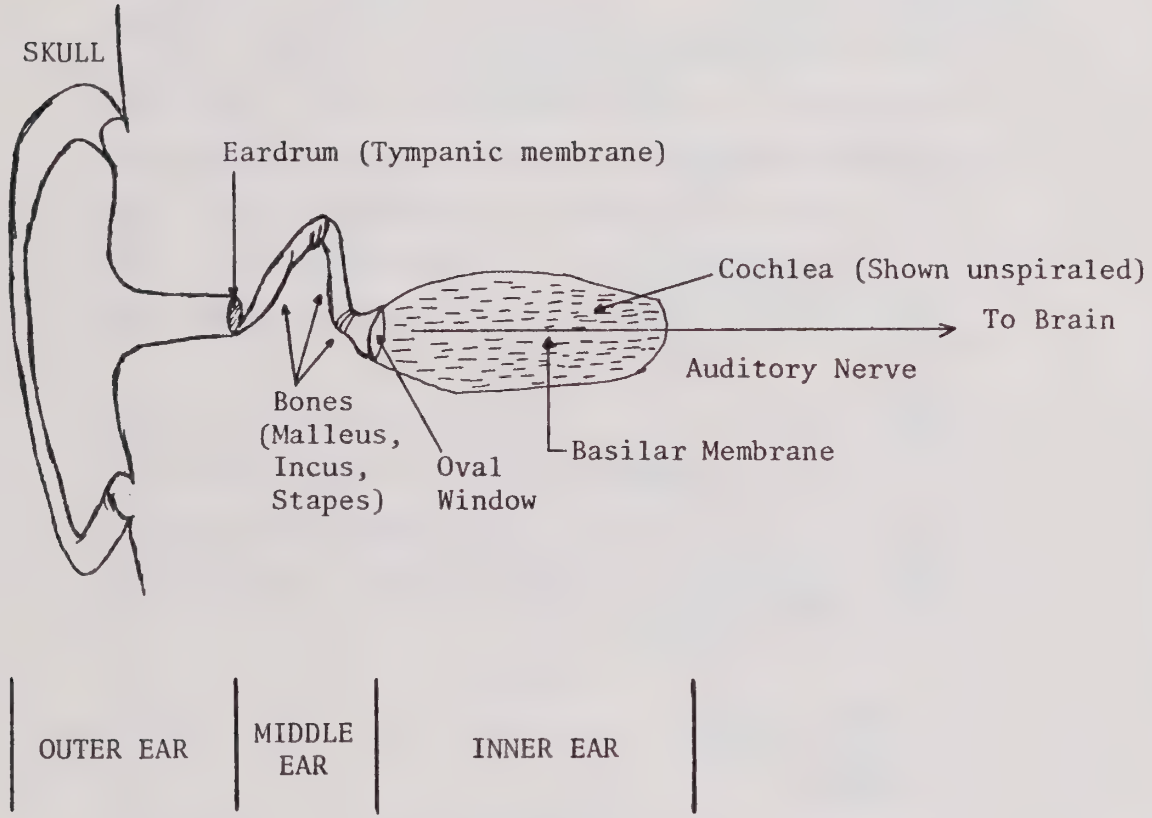


Figure 2-3. Simple functional diagram of the human ear. (After Kryter, 1970).

the dilation mechanism to protect it from overstimulation by light. It is thought that an analogous mechanism to dilation has not developed in the ear because the environmental stimulus, i.e. continuous exposure to loud noise, has not been present. Whether existing levels of noise in large cities is sufficient to initiate natural selection processes is difficult to say, but in any event such adaptation in man would take a long time. The human ear, then, is not well adapted to high levels of noise. This highlights the need to control loud noise before it reaches the ear.

There are a number of important aspects to the hearing process that enter into the evaluation of noise exposure in this Element. One is that the ear does not perceive all frequencies of sound equally. Generally, people are more sensitive to sounds in the higher frequencies than lower frequencies. This means that it takes a greater magnitude low frequency sound to be perceived as equal in loudness to a high frequency sound. This fact is accommodated in noise measurement by the use of an electronic filter in sound level meters that enables a meter to approximate the response of the human ear. Such measures are made by using the A scale of a meter, and are denoted by the letter A in the abbreviation dBA. Other measurement scales are the B and C scales which discriminate less against the lower frequencies, and therefore show somewhat higher decibel readings than the A scale (Figure 2-4).

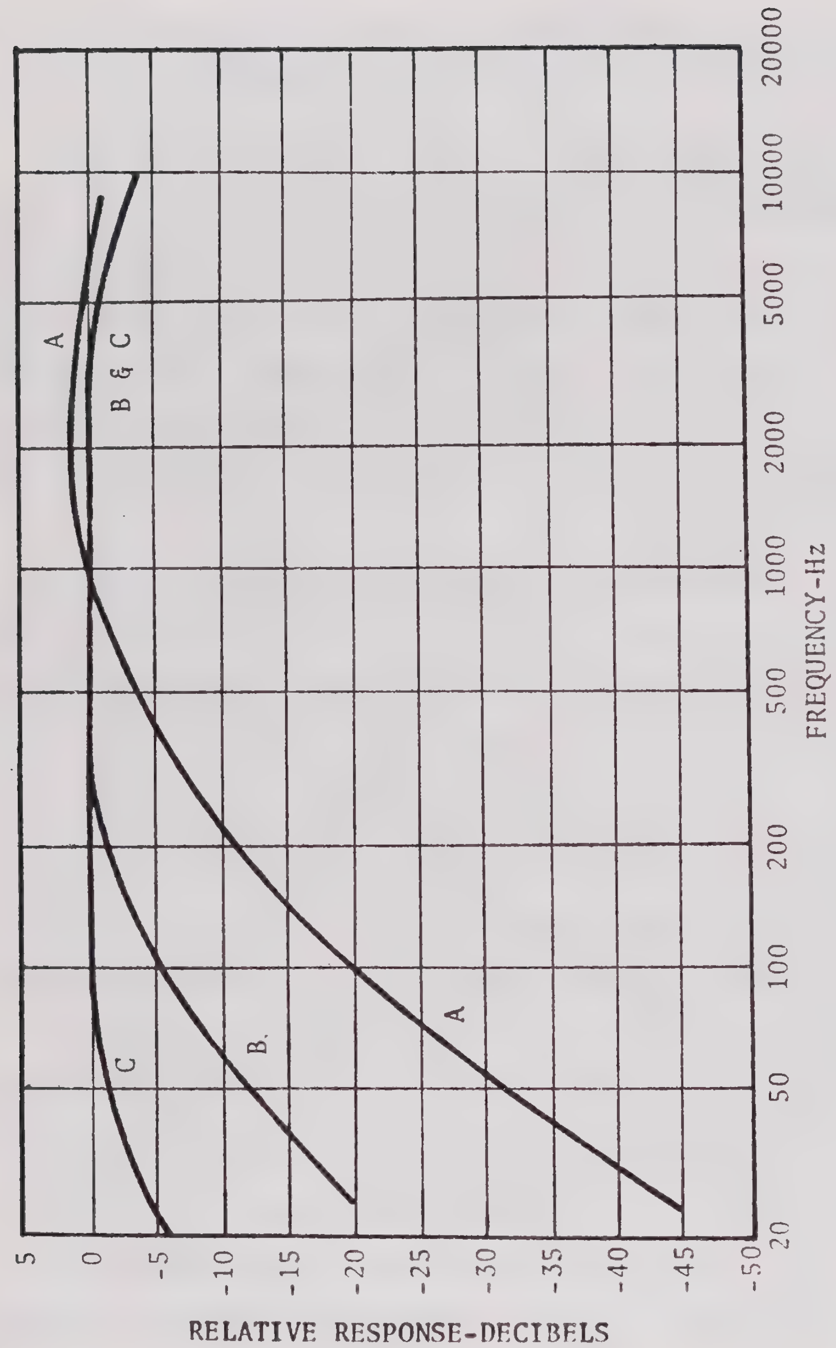


Figure 2-4. Frequency-response characteristics in the American National Standard Specification for A, B, and C scales in sound level meters. (Source: Peterson, 1972)

Another characteristic of human perception of sound is that it takes much more than twice a reference sound energy level to perceive a doubling in loudness. The average person can detect a difference in sound level at 2dB, but laboratory hearing tests indicate that it takes about a 10 decibel increase for most people to perceive a doubling of loudness. Field experimentation with aircraft noise indicate that the doubling of loudness can be perceived over a wide range, but the 10dB increase per doubling of loudness is an accepted rule of thumb.

To give a better idea of the everyday meaning of some of the above concepts, Table 2-1 provides a number of examples of sound sources, their approximate decibel output and relative energy content, and the human response to those sounds.

C. NOISE

1. General

At what point does sound become noise? The answer to this question is difficult primarily because of the subjective nature of noise. The American National Standards Institute (ANSI) defines noise as (1) any erratic, intermittent, or statistically random oscillation, or (2) any unwanted sound. It is the definition of noise as unwanted sound that causes difficulty in specifying what is noise and what is not. A common example of the diffi-

Table 2-1

Sound Levels and Human Response

Relative Sound Energy	Noise Level, dBA	Example	Response	Relative Loudness (Approximate)
1 quadrillion	150	Carrier Deck Jet Operation		32,768
100 trillion	140		Initial Pain Threshold	16,384
10 trillion	130			8,192
			Initial Discomfort Threshold	
1 trillion	120	Jet Takeoff (200 feet) Auto Horn (3 feet)	Maximum Vocal Effort	4,096
100 billion	110	Riveting Machine Jet Takeoff (2000 feet)		2,048
10 billion	100	Garbage Truck		1,024
1 billion	90	Heavy Truck (50 feet)	Very Annoying Hearing Damage (8 hours)	512
100 million	80	Alarm Clock	Annoying	256
10 million	70	Freeway Traffic (50 feet)	Telephone Use Difficult Intrusive	128
1 million	60	Air Conditioning Unit (20 feet)		64
100,000	50	Light Auto Traffic (100 feet)		32
10,000	40	Bedroom Library	Quiet	16
1,000	30	Soft Whisper (15 feet)	Very Quiet	8
100	20	Broadcasting Studio		4
10	10		Just Audible	2
1	0		Threshold of Hearing	1

culty is music. What may be rock and roll music to some is noise to others. Resolution of this problem at the community level requires a large measure of public participation in defining "acceptable sound".

The sources of noise may be thought of as either indoor or outdoor sources. Indoor noise includes all of those devices and machines in the homes, offices, and factories that can create sounds loud enough to damage hearing, interfere with speech communication, and arouse a person from sleep. The primary concern of this Element, however, is outdoor noise. Outdoor noise can be considered in five categories: transportation, construction work, industrial operations, the individual human being (shouting, playing radio too loudly), and miscellaneous noises such as air conditioning units attached to windows or the banging of garbage cans and lids. Of these different categories, noise generated by transportation is the most serious. Transportation accounts for the most continuous, and, in many areas, the loudest noise in urban centers. The emphasis of this Element is on evaluating and planning for transportation noise with a secondary emphasis on stationary noise sources.

Transportation noise sources are considered in this report in two categories: road and rail traffic noise. Air traffic noise is a mandated part of the Noise Element, and will be discussed in the forthcoming document prepared under the auspices of the San Luis Obispo Area Coordinating Council.

2. Road Traffic Noise

Within San Luis Obispo, road traffic is the most significant source of noise in terms of continuity and the size of area impacted. This is a result of there being more auto and truck traffic per day in the City than there is rail or air traffic.

Road traffic noise is generally dominated by emissions from automobiles and heavy diesel trucks. There are five other categories of vehicular noise sources: motorcycles, sport cars, light trucks, large gasoline-engine trucks, and buses. Generally, motorcycles and sport cars are noisier than automobiles because of higher engine speeds and less adequate muffling. Light trucks emit noise levels that are similar to automobiles, while the larger gasoline-fueled trucks are noisier than cars but quieter than diesel-fueled trucks of equal size. Buses are much noisier than automobiles on city streets, but are quieter than diesel trucks on the highway because they are usually better muffled and maintained. As a group, these five types of vehicles usually comprise only a small percentage of the total daily traffic flow. Since their noise emissions are within the range defined by auto and truck emissions, their noise is generally assumed to be contained within the mix generated by cars and trucks.

The principal components of both automobile and truck noise are three: the engine, exhaust, and tires. Fans operating as part of the cooling system are a major contribution to engine noise; hot gases escaping out of the exhaust pipe creates noise in that area of the vehicle; and the escape of air from between tire treads and the road surface is the source of tire noise. Four major factors control the noise level of vehicles: speed, acceleration, road grade, and road surface. Generally, vehicular noise levels increase directly with increases in speed, acceleration, road grade, and with rougher road surfaces. Figures 2-5 and 2-6 show the generalized noise spectra of an auto and a truck operating on level, average road surfaces at highway speeds.

3. Rail Traffic Noise

In San Luis Obispo, rail traffic creates noise events which are usually widely separated in time, but which are intense. The two major components of rail traffic noise are locomotive noise and passenger or freight car noise.

The locomotive produces the most intense noise which is generally thought to be a function of speed and track bed gradient. The relationship between speed and noise output is less well established, however, than the relationship between grade and noise output. Locomotives pulling upgrade generate significantly more noise than those operating under level or downgrade conditions.

In contrast, car noise is dependent upon velocity and increases directly with increases in speed. The wheel-track interaction is also a primary factor in noise output. Jointed track, frogs and grade crossings, and tight

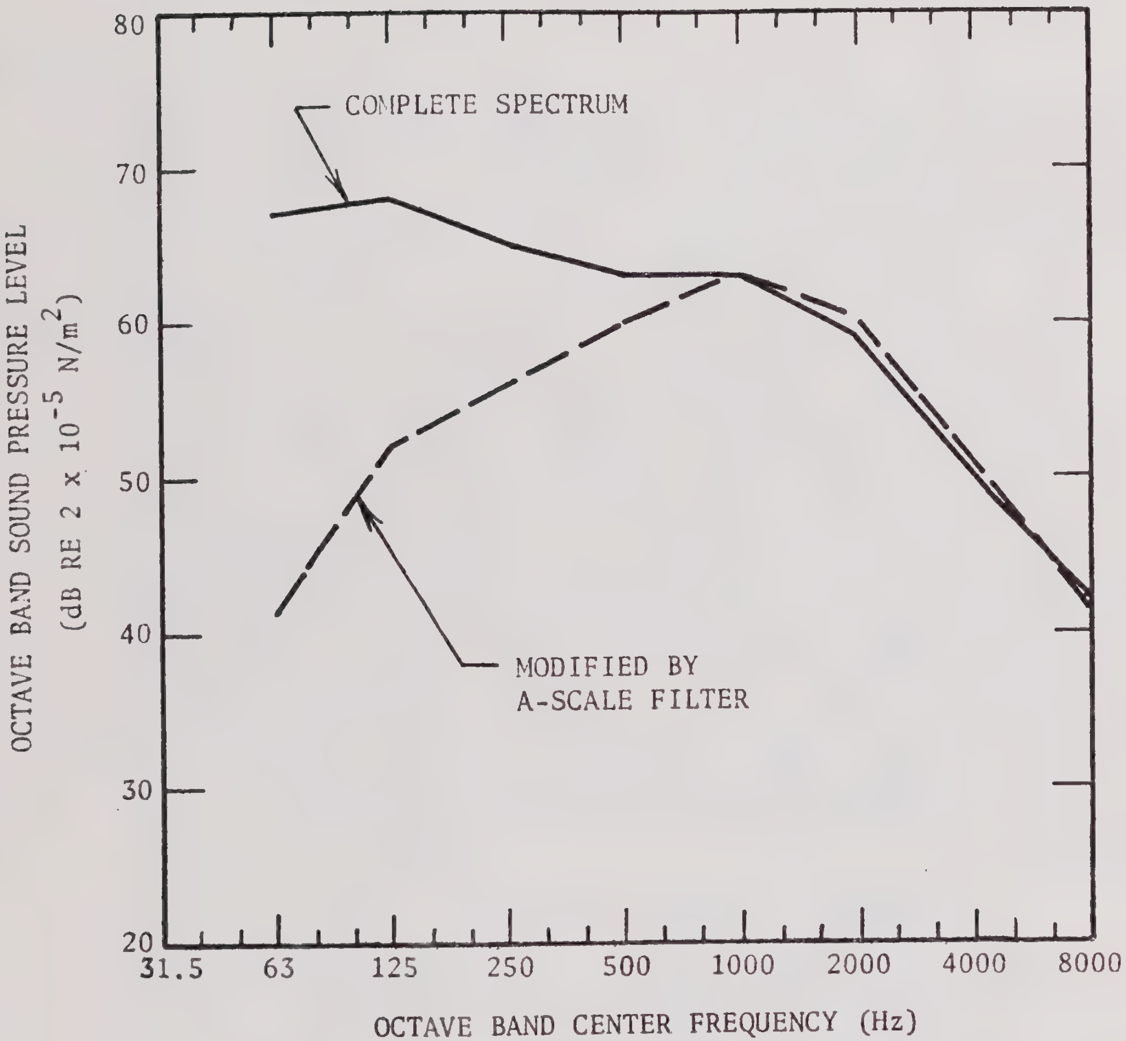


Figure 2-5. Generalized spectrum of typical passenger automobile at 50 mph speed and at 50 ft. distance. (Source: Bolt, Beranek, and Newman, Inc., 1973)

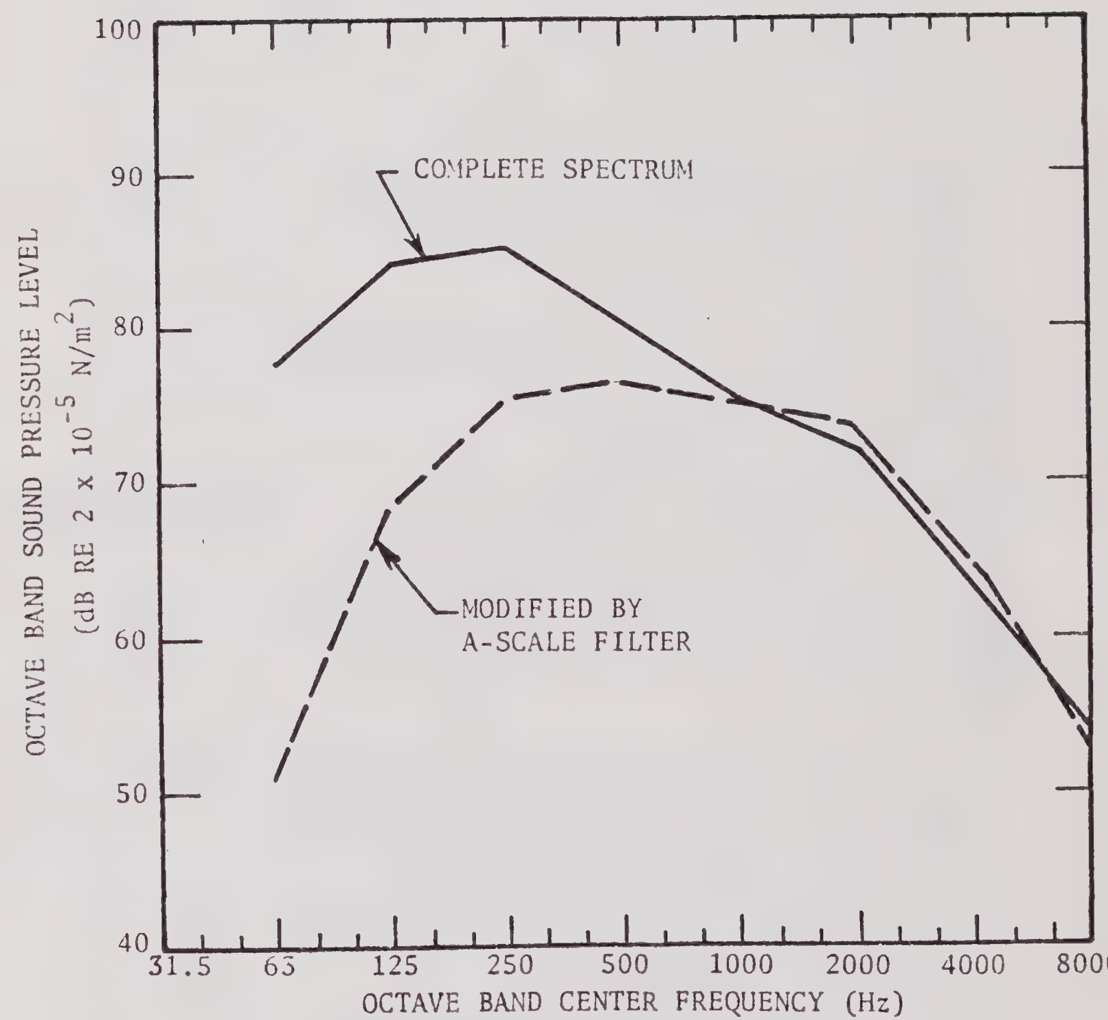


Figure 2-6. Generalized spectrum of typical diesel truck at 50 ft. distance on level roadway at highway cruising speeds. (Source: Bolt, Beranek, and Newman, Inc., 1973)

radius curves all act to increase the noise output of rail cars. Figure 2-7 shows an idealized noise history for a train-pass-by illustrating the locomotive and car components of train noise.

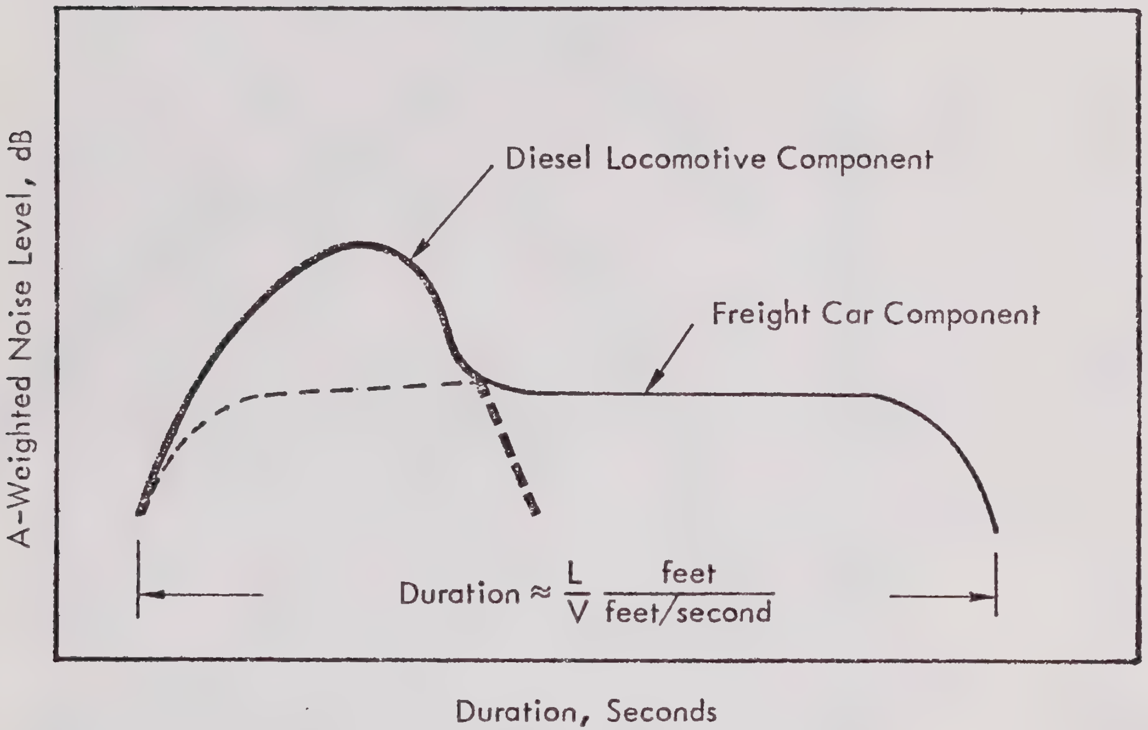


Figure 2-7. Idealized Time History of Train Passby Illustrating Locomotive and Freight Car Components. (Source: Wyle Laboratories, 1973)

II. METHODOLOGY

A. PHILOSOPHY OF ANALYSIS

When evaluating noise exposure, it is necessary to account for a number of diverse parameters. These include not only sound wave amplitudes and frequencies, but also the time characteristics of the noise, reverberation and attenuation by structures and other barriers, the hearing ability of individuals exposed, and their activity during exposure. Such a description entails the use of several numerical indicators and would be specific to a particular site and situation. However, when evaluting noise exposure on a city-wide basis, such a complete description would be impractical. It is necessary, then, to choose a less detailed but reliable descriptive scheme which results in a more general indicator of noise exposure and potential noise problems. This is the approach taken in the City of San Luis Obispo Noise Element.

The rating scheme used in this Element to describe transportation noise is the Day-Night Noise Level which results in a generalized single-number indicator of noise exposure. While the establishment of a completely valid single-number noise exposure index has been the goal of psychoacoustic experts for many years, no indicator has proven to be a fully adequate substitute for more complex descriptions. With that qualification in mind, it can be said that the single-number indices are useful tools in defining noise exposure for general planning purposes.

One other qualification regarding the noise exposures described in this report should also be noted. The noise levels were defined by use of a mathematical model which relies heavily on the validity of the input data. In a number of instances, these data were incomplete or not available, and it was necessary to make reasonable estimates. In developing these estimates, a conservative approach was taken at each stage of data analysis. The end result of this process is that the noise exposures represented by the contours may be somewhat high and could be considered to contain a "margin of safety". The intent of this approach is to ensure that any error introduced into the process is on the side of public benefit.

B. MEASUREMENT SCHEME: DAY-NIGHT NOISE LEVEL

In recent years there has been a proliferation of noise rating schemes or techniques, and different agencies of the Federal and State governments have adopted different techniques. The result has been a general confusion by both government administrators and the public. A resolution to this problem has yet to be found in a uniformly-accepted single-number index of noise exposure that can be applied to all types of noise sources and that accurately reflects human response to sound.

To date, the most promising noise exposure index to be developed is the Day-Night Noise Level (abbreviated L_{dn}).

This index is based on two premises regarding human response to sound. The first is that humans will respond to a steady noise over a given period of time in the same way that they will respond to a time-varying noise with an equivalent amount of sound energy as the steady noise. The second premise is that humans are generally more sensitive to noise during the night than during the day.

The dominant characteristic of transportation noise is that it is not steady. There are constant fluctuations which may or may not be widely separated in time. At any given moment near a freeway or rail line, it may quiet, but when traffic volumes or speeds increase that quiet is quickly displaced by high noise levels. Therefore, it is not appropriate to measure noise at any given moment, and call that the noise level of the source. A statistical approach is required to account for the time-varying nature of the sound. Such an approach, however, would yield a large number of statistics to show the day, night, weekday, weekend, fair and foul weather differences in noise levels. Such a large number of parameters make baseline noise level mapping and noise control enforcement extremely difficult, if not impossible to accomplish on a community-wide basis.

The problem of time-fluctuating noise levels is further complicated by the fact that people are exposed to different sources of noise as they move from place to place in the community. For example, a typical factory worker spends time in a relatively quiet residential setting during the night, drives to work in high noise traffic, works around loud machinery all day, except for a quieter period at lunch, and then returns home. This pattern of exposure to different noise levels increases the number of descriptive parameters needed to evaluate the total noise "dosage" of people as they move through the day, and complicates the task of setting standards to protect health and welfare.

To avoid a large number of noise indices, it became necessary for acousticians to develop single-number indicators. As the basis of such indicators, it has been shown that humans respond to steady noises in generally the same way as to fluctuating noises with equal energy content. The level of a constant sound which has the same sound energy as does a time-varying sound is termed the Equivalent Sound Level (abbreviated L_{eq}).

The L_{eq} concept was first introduced in Germany in 1965 to evaluate aircraft noise and has since received wide use in many countries. It has been adequately demonstrated that the L_{eq} can be used to describe the noise levels which cause annoyance and lead to permanent hearing loss.

The Day-Night Noise Level is based on the L_{eq} and the pre-

mise that noise at night is more annoying than daytime noise. This is primarily a reflection that most people sleep during the night. The L_{dn} uses the A-scale weighted L_{eq} as the basic expression of noise levels, over a 24-hour period, but applies a 10 dB penalty to the noise which occurs during the night hours (defined as 10:00 pm to 7:00 am). This means that the method makes all noise levels measured at night 10 dB higher than they actually are. The L_{dn} represents an evolution of a noise measurement scheme called the Community Noise Equivalent Level (CNEL) which applied a weighting of 3 dB to noise which occurred during an evening period defined as 7:00 pm to 10:00 pm. CNEL and L_{dn} noise levels usually agree within plus or minus 1 dB, and the evening noise weighting has not been shown to be a better indicator of human response.

The considerations discussed above form the basis of the rationale for selecting the L_{dn} as the noise evaluation scheme for the Noise Element. In summary, the L_{dn} has the following desirable characteristics:

1. The L_{dn} utilizes A-scale measurements of noise corrected for time-variance and nighttime exposure, and therefore is a reliable single-number index of human response to noise.
2. The measure can be applied to any source of environmental noise providing a common scale to compare (and add) noise exposure from different sources.
3. The measure can be easily calculated from sound level meter recordings.
4. The measure can be used in predictive methodologies to estimate future noise levels.

C. MATHEMATICAL MODELING

1. General

The transportation noise environment delineated on the Noise Contour Map was developed through calculations of L_{dn} noise levels according to mathematical models developed by Wyle Laboratories. These models are based on a large sample of field noise measurements of road and rail traffic, and predict L_{dn} noise levels as functions of specified traffic data.

A modeling approach was taken in developing the noise contours for two reasons: (1) collection of input data for the models was more practical than collection of field measurements under the time and budget constraints of the study, and (2) modeling techniques for L_{dn} noise levels have been shown to be just as reliable as calculations based on field measurements. As a basis for this second reason, it should be remembered that the L_{dn} is not measured directly, but is calculated from measurements. These calculations require making estimates and developing averages that are subject to the same limits of error as mathematical modeling.

The exact expression of L_{dn} levels is founded in integral calculus. For applications to road and rail traffic, however, it is possible to approximate the L_{dn} by expressions which avoid computation of the integral, and are accurate to within less than plus or minus 1 dB. The basic expression is:

$$L_{dn} = \overline{SENEL} + 10 \log N - 49.4$$

where,

$\overline{SENEL}$ = Average Single Event Noise Exposure Level

N = Number of road or rail operations

49.4 = a normalization factor equal to 10 log (3600x24).

and where,

$$SENEL = L_{max} + 10\log_{10} t_{ea}, \text{ dB}$$

with,

L_{max} = maximum noise level as observe on the A scale of a standard sound level meter

t_{ea} = effective time duration of the noise level in seconds. It is about equal to ½ of the "10 dB down duration" or the duration for which the noise level is within 10 dB of L_{max}.

and,

$$N = N_D + 10N_N$$

with,

N_D = Number of operations between 7:00 am and 10:00 pm.

N_N = Number of operations between 10:00 pm and 7:00 am.

The value of the modeling procedure is that the SENEL has been defined through sample measurements and correlated to such factors as vehicle speed and acceleration. This kind of information, then, along with the number of operations can be used to predict the L_{dn} noise levels. Other factors, such as existing noise barriers, can also be accounted for through modeling in estimating the propagation of noise into the community.

2. Input Data

The importance of the input data in mathematical modeling cannot be understated. The accuracy of the final estimate relies heavily on this information as a description of the "real world". The following lists of information describe the kind of input data used in calculating the L_{dn} noise levels of rail and road traffic. The specific compilation of this information for the City of San Luis Obispo is contained in Appendix A.

(a) Road Traffic Data

1. List of roads selected for evaluation.
2. Road segment identification as defined by the following parameters (No. 3 through 9). When one of these parameters changes, a new road segment is defined.

3. Average Daily Traffic (ADT) broken down into hourly flows for the daytime (7:00 am to 10:00 pm) and the nighttime (10:00 pm to 7:00 am).

4. Lane configurations: number of lanes and average width of median strip divides, if any.

5. Percentage of diesel truck traffic on the road segment.

6. Representative speeds for road segments as determined by the posted speed limit and observations of variations to that limit.

7. Road grade conditions: mild (0 to 2 percent), moderate (3 to 5 percent), and severe (greater than 6 percent).

8. Lane distribution of road traffic by vehicle class, i.e. if the road has more than two lanes, what percent of total cars (and trucks) are in each lane.

9. Road sideline terrain characteristics, i.e. is the sideline elevated, depressed, or level with the roadbed.

(b) Rail Traffic Data

1. Line segment identification.

2. Representative train speeds.

3. Average train lengths.

4. Grade conditions. Grades are considered in three categories: Level (within $\pm$ 0.75 percent), upgrade (greater than + 0.75 percent) and downgrade (greater than - 0.75 percent).

5. Sideline Characteristics.

6. Identification of track characteristics:

   (1) Mainline welded or jointed track

   (2) Low speed clasified jointed track

   (3) Presence of switching frogs or grade crossings

   (4) Tight radius curves
      a. radius less than 600 feet
      b. radius 600 to 900 feet
      c. radius greater than 900 feet

   (5) Presence of bridgework
      a. light steel trestle
      b. heavy steel trestle
      c. concrete structure

7. Number of operations broken down into the number of day and night operations.

The information describing road traffic in the City was provided by the City's Department of Community Development, while rail traffic data were provide by the Southern Pacific Transportation Company.

D. NOISE CONTOURING

The information described in the preceding section was used to predict L_{dn} noise levels generated by road and rail traf-

fic in the City through the models published by Wyle Laboratories in Development of Ground Transportation Systems Noise Contours for the San Diego Region, Wyle Research Report WCR 73-8, (road traffic noise) and Assessment of Noise Environments Around Railroad Operations, Wyle Research Report WCR 73-5, (rail traffic noise). These noise levels are represented on the Noise Contours Map by L_{dn} noise contours. The contours are lines connecting points of equal sound intensity. They form bands 5 dBA in width along the roads and railroad.

Some attempt was made in this analysis to account for the attenuative effects of the more significant sideline features along the freeway and rail line. These are primarily the areas in which the route is depressed relative to the surrounding topography or is immediately adjacent to a large elevation. The effect of these sideline features is to attenuate the propagation of higher sound levels into the community. This is represented by the contour lines being closer together. Analysis of attenuation and reverberation due to small sideline features, such as buildings, is beyond the scope of this analysis, and would not be appropriate to noise evaluation at a city-wide level for general planning purposes. It should be remembered, then, that the noise contours are general indicators of noise exposure and not precise levels.

The preparation of the noise contour map involved a certain amount of estimating and smoothing. For example, the contour lines at intersections of roads were rounded away from the intersections indicating an increase in noise levels. Intersections are generally noisier than line sources because traffic volumes increase there. Additionally, many vehicles (e.g. trucks) create more noise under stop-and-go conditions than at steady speeds. The rounding of the contour lines represents this condition, but is not an exact estimate of the magnitude. Precise estimates should be made through site analysis.

Government Code Section 65302(g) requires that the noise contours be continued down to 65 dBA except for regions involving medical or mental health care facilities and outdoor recreation areas. In these latter areas, the contours are to be continued down to 45 dBA. The procedure used in this Element was to carry the contours down to 55 dBA in all areas, and to 45 dBA in the areas specified in the State Code. It should be noted, however, that the accuracy of the 50 dBA and 45 dBA contours is open to considerable question. These are very low noise levels and they occur at such long distances from the sources that it is difficult to attribute them to the transportation source at all. For example, an open field in a low density residential area would measure at about 40 dBA. A bird chirping in that field can increase the sound level to 50 dBA. Other sources, then, can exceed 50 dBA at long distances from a freeway or

railroad making it difficult to determine the sound level generated by the freeway or railroad.

III. NOISE ENVIRONMENT

A. NOISE SENSITIVE LAND USES

The Noise Contours Map shows the location of parks, schools, and hospitals as examples of noise sensitive land uses. The omission of other land uses from the map is not intended to imply that these are the only noise sensitive uses. Rather, these are the examples listed in the Government Code.

All land uses may be considered to be sensitive to noise, but to different levels. Land use sensitivities may be thought of as a continuum with some uses able to tolerate a high level and others unable to tolerate any but the quietest level. The level of tolerable or "acceptable" noise is a function of the subjective desires of the community, and the average exposure times of people in different areas. This latter concept is related to the premise underlying the Sound Equivalent Level. That is, it is acceptable to be exposed to high noise levels for part of the day as long as this exposure is compensated by being in a quiet environment latter on. For example, the acceptable noise level for industrial land use is 75 dBA (L_{dn}). A person working in that environment, however, should be compensated by spending a certain amount of time in an interior residential area where the acceptable noise level is 45 dBA (L_{dn}).

The land use noise standards recommended in the Policy Statement serve, in effect, to define the sensitivity of each land use. The maximum acceptable noise level for a land use is the level dividing the "Normally Acceptable" and "Normally Unacceptable" noise levels. This definition can be used in identifying potential noise conflict areas as described in the following section.

B. NOISE CONFLICT AREAS

Potential noise conflict areas are shown on the Noise Contours Map as cross-hatched areas of the noise sensitive uses listed on the map. These conflict areas are those sections of an existing or proposed land use exposed to noise levels which are incompatible with that use of the land. They are termed "potential" noise conflict areas because both the land use and noise exposure representation are generalized. A site analysis might show then that the particular area in conflict is not as sensitive as the general land use. For example, most of the conflict areas of hospitals occur within 100 or 200 feet of the roadway. It could be that these areas are used for parking rather than hospital wards. It could also be that structures or other noise barriers exist at the site which reduce the noise to acceptable levels. The intent of identifying these noise conflict areas, then,

is to point out those places which deserve site analysis in a noise control program.

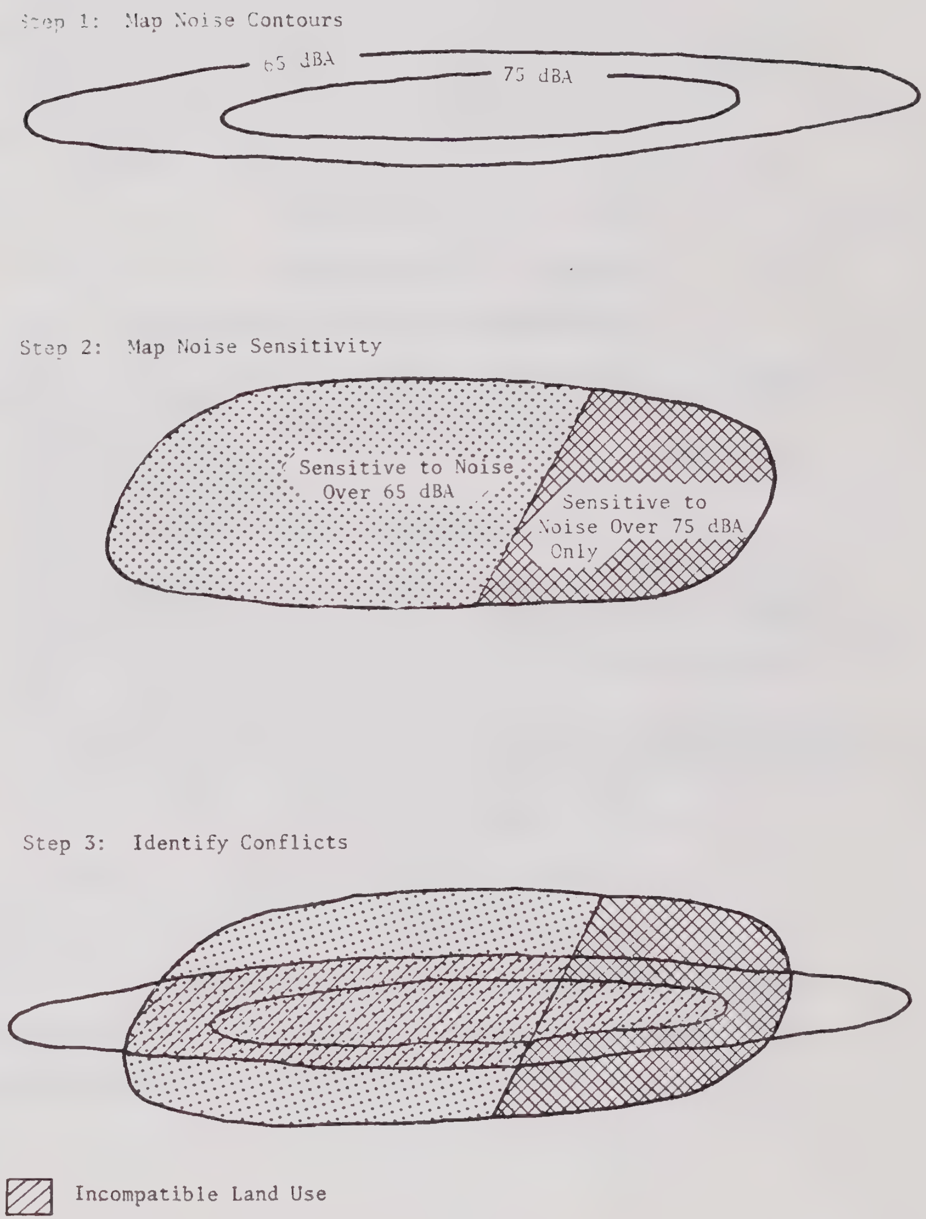
The actual identification of a noise conflict area is a simple, graphical problem given the noise sensitivities of various land uses and a noise contours map. By overlaying a land use map with a noise contours map, identification of conflicts can be made directly as illustrated in Figure 2-8. Once these conflict areas have been identified, it is recommended that a site analysis be conducted to determine the precise nature of the noise problem, if any is confirmed to exist.

C. NOISE EXPOSURES

Noise exposures from road and rail traffic in San Luis Obispo are presented in quantitative form both graphically, on the Noise Contours Map, and in tabular form in Appendix B. Noise from rail traffic is represented on the Noise Contours Map by dashed-line notation while road traffic noise is represented by solid line notation. In many instances, a site may be exposed to noise from both sources. The total noise exposure of the site may be calculated by combining the noise levels according to the "decibel addition" chart (Figure 2-2). For reference, the total noise exposure may be compared to the common noise exposure experiences shown in Table 2-1.

FIGURE 2-8

NOISE CONFLICT MAPPING



Analysis of the Noise Contours Map shows that except for areas near US 101, the Southern Pacific rail line, certain major arterials, and the downtown area, most of the City can be considered to be fairly quiet with respect to road and rail traffic noise. Potential noise conflict areas were identified in areas of five of thirty-two noise sensitive land uses which were mapped. These areas are listed in Table 2-2.

Table 2-2

Potential Noise Conflict Areas

Noise Sensitive Areas	Local Noise Sources
French Hospital	Johnson Avenue Southern Pacific Rail Line
County Hospital	Johnson Avenue
Laguna Lake Park Site	Madonna Road
Sinsheimer Park	Southern Pacific Rail Line
San Luis Obispo Senior and Junior High Schools	Southern Pacific Rail Line

It should be stressed again that these are only potential noise problem areas. Specific site analysis is necessary to give precise definition to any noise problem, if one is confirmed to exist. Noise conflict mapping for other land uses may reveal additional potential noise conflict areas.

It should also be noted that the noise contours represent only road and rail traffic generated noise. Stationary source noise and air traffic noise will be identified as part of the complete Noise Element being prepared by the San Luis Obispo Area Coordinating Council. These contours will not account for interior noise or outdoor noise generated by construction work, individual persons, or miscellaneous noises such as window air conditioning units.

IV. CONCLUSIONS

The following conclusions and recommendations are a summary of the major technical findings of the analysis regarding noise exposure from road and rail traffic in the City of San Luis Obispo.

1. Of road and rail traffic noise, the major source of environmental noise in San Luis Obispo is road traffic. Road traffic noise impacts a larger area than rail traffic and is a source of more continuous noise. The most significant single source of road traffic noise is US 101.

2. The Southern Pacific Railroad line is second to US 101 as the most significant source of environmental noise. Noise events on the rail line are infrequent, but create intense levels of noise such that their total sound energy is nearly equivalent to that of the freeway which carries much higher traffic volumes.

3. Other important noise sources are the following major arterial streets: Madonna Road, Foothill Boulevard, Santa Rosa Street, Monterey Street, and Johnson Avenue.

4. Potential noise problem areas have been identified at the following sites: French Hospital, County Hospital, Laguna Lake Park Site, Sinsheimer Park, and the San Luis Obispo Senior and Junior High Schools. Site acoustic studies should be conducted to define the precise nature of the noise problems, should any be confirmed to exist.

5. Noise conflict mapping should be conducted for land use categories not included in this analysis to identify other potential noise problem areas in the City. Once these areas are identified, site acoustic studies should be conducted to define the situation.

6. Proposed developments in the City should be located on a Noise Contours Map to determine if there is a potential impact on the development, or conversely, if the development will increase noise levels in a relatively quiet area. Based on this initial analysis it should be determined whether a detailed site study should be conducted. It is recommended that site studies be conducted in all areas identified as potential noise conflict areas.

GENERAL REFERENCES

General References

1. Baron, R.A. The Tyranny of Noise. 1970.

2. Bolt, Beranek, and Newman, Inc. Fundamentals and Abatement of Highway Traffic Noise. National Technical Information Service. 1973.

3. Bolt, Beranek, and Newman, Inc. Noise Element, North Los Angeles County General Plan, Preliminary Draft. 1974.

4. California Council on Intergovernmental Relations. General Plan Guidelines. CIR. 1973.

5. Houle, G.F. Toward the Comprehensive Abatement of Noise Pollution: Recent Federal and New York City Noise Control Legislation (in Ecology Law Quarterly, vol. 4:109). 1974.

6. Kryter, K.D. The Effects of Noise on Man. 1970.

7. Peterson, A.P. and Gross, E.E. Handbook of Noise Measurement. General Radio. 1972.

8. Schultz, T.J. and McMahon, N.M. Noise Assessment Guidelines. 1971

9. Stevenson, G.M. Noise and the Urban Environment in Detwyler, T.R. Urbanization and Environment. 1972.

10. Swing, J.W. Development of Ground Transportation Systems Noise Contours for the San Diego Region. Wyle Laboratories. 1973.

11. Swing, J.W. and Pies, D.B. Assessment of Noise Environments Around Railroad Operations. Wyle Laboratories. 1973.

12. US Environmental Protection Agency. The Economic Impact of Noise. 1971.

13. US Environmental Protection Agency. Noise Pollution. Report No. 0-470-370. 1972.

14. US Environmental Protection Agency. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, Reprot No. 55019-74-004. 1974.

15. US Department of Transportation. The Audible Landscape: A Manual for Highway Noise and Land Use. 1974.

16. Wyle Laboratories. Final Report: Home Sound Proofing Pilot Project for the Los Angeles Department of Airports, Report No. WCR 70-1. 1970.

APPENDICES

APPENDIX A

TRAFFIC DATA COMPILATIONS

Traffic Data Compilations

The tables contained in this appendix show the traffic data used in calculating the L_{dn} noise levels from road and rail traffic in the City of San Luis Obispo. As noted in the report section discussing the philsophy of the technical analysis, it was sometimes necessary to make reasonable assumptions or estimates in collecting some of these data. The most significant of these assumptions regarding road traffic are: (1) nighttime traffic flows are approximately equal to 13% of the 24 hour ADT, (2) peak hour flows are approximately equal to 10% of the 24 hour ADT, and (3) truck traffic flows are approximately equal to 4% of the daytime flow during the day and 2% of the nighttime flow during the night (except on certain segments as noted). It should be noted that the hourly traffic volumes shown in the table are peak hour volumes, rather than average volumes. This factor essentially serves to make the noise level calculations a "worst case" analysis, and makes a significant contribution to making the noise level estimates conservative.

Average train traffic volumes were used in calculating L_{dn} noise levels from this source because accurate information regarding the total number of operations was available from the Southern Pacific Transportation Company. The day-night distribution of traffic was not available, however, so the estimate of three train operations during the night period is an assumed estimate.

The explanation of the column headings in the Tables A-1 and A-2 is contained in the Methodology section of the Technical Analysis under Part C2, "Input Data".

TABLE A-1. ROAD TRAFFIC DATA, CITY OF SAN LUIS OBISPO, 1975

Route	Road Segment	Average Speed, mph	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	>6	E	L	D
Johnson Avenue	Mill Street to Monterey Street	35	2/0	260	40	4	2	x				x	
	Monterey Street to Marsh Street	35	2/0	435	65	4	2	x				x	
	Marsh Street to Pismo Street	35	2/0	780	120	4	2	x				x	
	Pismo Street to Breck Avenue	35	3/0	1000	150	4	2			x		x	
	Breck Avenue to Bishop Street	35	4/0	1650	250	4	2			x		x	
	Bishop Street to Laurel Lane	35	4/0	1040	160	4	2			x		x	
	Laurel Lane to Orcutt Road	35	4/0	260	40	4	2			x		x	
Higuera Street	Santa Rosa Street to Chorro Street	30	3/0	920	80	4	2	x				x	
	Chorro Street to Nipomo Street	30	3/0	830	70	4	2	x				x	
	Nipomo Street to Marsh Street	30	3/0	550	50	4	2	x				x	
	Marsh Street to High Street	30	4/0	735	65	4	2	x				x	

TABLE A-1 (Continued)

Route	Road Segment	Average Speed, mph	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	> 6	E	L	D
	High Street to Madonna Road	30	4/0	1425	125	4	2	x				x	
	Madonna Road to Elks Lane	30	2/0	900	80	4	2	x				x	
	Elks Lane to Prado Road	30	2/0	365	35	4	2	x				x	
	Prado Road to Los Osos Valley Rd.	30	2/0	180	20	4	2	x				x	
Foothill Blvd.	City limits to Tassajara Drive	40	4/0	690	60	4	2	x				x	
	Tassajara Drive to Santa Rosa Street	30	4/0	1420	125	4	2	x				x	
	Santa Rosa Street to Crandall Street	30	4/0	550	50	4	2	x				x	
Tank Farm Road	South Higuera Street to Edna Road	50	2/0	140	15	4	2	x				x	
Los Osos Valley Rd.	City limits to Royal Way	35	4/0	890	60	4	2	x				x	

TABLE A-1 (Continued)

Route	Road Segment	Average Speed, mph	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	>6	E	L	D
	Royal Way to Madonna Road	35	4/0	1090	930	4	2	x				x	
	Madonna Road to US 101	35	2/0	325	45	4	2	x				x	
Madonna Road	Higuera Street to US 101	35	4/0	1420	110	4	2		x		x		
	US 101 to Oceanaire Dr.	35	4/0	1735	135	4	2	x				x	
	Oceanaire Dr. to Los Osos Valley Rd.	35	4/0	1150	90	4	2	x				x	
Mill Street	Chorro Street to Johnson Avenue	30	2/0	325	25	4	2	x				x	
	Johnson Avenue to SPRR	30	2/0	270	20	4	2	x				x	
	SPRR to Grand Avenue	30	2/0	90	10	4	2	x				x	
Monterey Street	Santa Rosa Street to Johnson Street	25	2/0	1400	130	4	2	x				x	
	Johnson Avenue to Grand Ave.	25	2/0	960	90	4	2	x				x	

TABLE A-1 (Continued)

Route	Road Segment	Average Speed, mph	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	>6	E	L	D
	Grand Avenue to US 101	35	2/0	495	105	4	2		x			x	
Chorro Street	Highland Drive to Foothill Blvd.	30	2/0	620	80	4	2	x				x	
	Foothill Blvd. to US 101	30	2/0	800	100	4	2	x				x	
	US 101 to Marsh Street	30	2/0	1100	150	4	2	x				x	
	Marsh Street to Broad Street	30	2/0	240	30	4	2	x				x	
Broad Street (Edna Road)	Higuera Street to Chorro Street	25	2/0	550	50	4	2		x			x	
	Chorro Street to Lawrence Drive	35	2/0	990	60	4	2	x				x	
	Lawrence Drive to Tank Farm Road	35	2/0	720	80	4	2	x				x	
	Tank Form Road to Buckley Road	35	2/0	490	60	4	2		x			x	

TABLE A-1 (Continued)

Route	Road Segment	Average Speed, mph	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	>6	E	L	D
Patricia Drive	Foothill Blvd. to Westmont Street	25	2/0	380	20	4	2	x				x	
Grand Avenue	Monterey Street to Slack Street	35	4/0	460	40	4	2	x	x			x	
Osos Street	US 101 to Islay Street	30	2/0	440	60	4	2	x	x			x	
Santa Barbara Avenue	Islay Street to Broad Street	30	2/0	700	100	4	2	x				x	
Marsh Street	US 101 to Higuera Street	25	4/0	370	30	4	2	x			x		
	Higuera Street to Broad Street	25	3/0	550	50	4	2	x				x	
	Broad Street to Santa Rosa Street	25	3/0	930	70	4	2	x				x	
	Santa Rosa Street to Johnson Street	25	3/0	790	60	4	2	x				x	
	Johnson Avenue to California Blvd.	25	2/0	620	50	4	2		x			x	

TABLE A-1 (Continued)

Route	Road Segment	Average Speed, mph	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	>6	E	L	D
California Street	Foothill Blvd to Hathaway Avenue	25	2/0	530	60	4	2	x				x	
	Hathaway Avenues to US 101	25	2/0	1030	120	4	2		x			x	
	US 101 to Johnson Avenue	25	2/0	670	80	4	2			x		x	
Pismo Street	Higuera Street to Osos Street	30	2/0	320	30	4	2	x				x	
	Osos Street to Johnson Avenue	30	2/0	650	50	4	2	x				x	
Laurel Lane	Orcutt Road to Southwood Drive	40	4/0	600	120	4	2	x				x	
	Southwood Drive to Johnson Avenue	40	4/0	370	70	4	2	x				x	
Orcutt Road	Broad Street to Laurel Lane	45	2/0	600	120	4	2			x		x	
	Laurel Lane to Johnson Avenue	45	2/0	160	20	4	2			x		x	

TABLE A-1 (Continued)

Route	Road Segment	Average Speed, mph	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	6	E	L	D
Santa Rosa Street	Foothill Blvd. to Murray Street	30	4/0	1650	250	4	2	x				x	
	Murray Street to US 101	30	4/0	1910	290	4	2	x				x	
	US 101 to Monterey Street	30	4/0	1210	190	4	2		x			x	
	Monterey Street to Marsh Street	30	2/0	950	150	4	2		x			x	
	Marsh Street to Railroad Station	30	2/0	430	70	4	2	x				x	
Hwy 1	City limits	35	4/20'	1450	150	6	4		x			x	
US 101	South City Limits to Madonna Road	55	4/30'	1990	360	9	20	x				x	
	Madonna Road to Marsh Street	55	4/30'	2720	480	9	20	x					x
	Marsh Street to Nipomo St.	55	4/30'	2420	430	9	20	x				x	
	Nipomo Street to Broad St.	55	4/30'	2420	430	9	20	x				xE	xw
	Broad Street to Chorro St.	55	4/30'	2420	430	9	20	x				x	

TABLE A-1 (Continued)

Route	Road Segment	Average Speed, mpg	Lanes/ Median (feet)	Peak Hourly Flow		% Trucks		% Grade			Sideline		
				Day	Night	Day	Night	0-2	3-5	6	E	L	D
	Santa Rosa Street to California Street	55	4/30'	2120	380	9	20	x					x
	California Street to Turner Avenue	55	4/30'	1610	280	9	20		x				x
	Turner Avenue to Grand Avenue	55	4/30'	1610	280	9	20		x			x	
	At Grand Avenue	55	4/30'	1610	280	9	20	x					
	Grand Avenue to Buena Vista	55	4/30'	1610	280	9	20	x				x	
	At Buena Vista	55	4/30'	1610	280	9	20	x					x
	Buena Vista to Monterey Street	55	4/30'	1610	280	9	20	x				x	
	Monterey Street to N. City Limits	55	4/30'	1480	260	9	20	x			xs		xn

TABLE A-2. RAIL TRAFFIC DATA, CITY OF SAN LUIS OBISPO, 1975

Line	Segment	Speed, mph	Train Length, feet	% Grade	No. of Operations	
					Day	Night
SPTC Line "E", Coast Route	North City Limits to Pismo St.	40	Freight: 6000 Passenger: 1000	1.0, down, southbound	7	3
	Pismo St. to Orcutt Road	25		1.0, down, southbound	7	3
	Orcutt Road to South City Limits	35		1.0, up, southbound	7	3

APPENDIX B

DISTANCES TO L_{dn} NOISE LEVELS
FOR EXISTING ROAD AND RAIL TRAFFIC OPERATIONS

Distances to L_{dn} Noise Levels for Existing Road and Rail Traffic Operations

Tables B-1 and B-2 are a compilation of the data used to develop the Noise Contours Map. This information may be used as a supplement to the Map in defining the noise exposure and identifying potentially incompatible land use areas. The distances shown are from the centerline of the railroad track or roadway to the noise level shown.

TABLE B-1. Distances to L_{dn} Noise Levels, Road Traffic Noise

Route	Segment	L_{dn} Noise Level, dBA, at 50 feet	Distances to L_{dn} Noise Levels (from ℄, in feet)						
			75	70	65	60	55	50	45
Johnson Avenue	Mill Street to Monterey Street	64	-	-	-	90	200	430	920
	Monterey Street to Marsh Street	65	-	-	-	110	230	500	1070
	Marsh Street to Pismo Street	66	-	-	60	130	270	580	1210
	Pismo Street to Breck Street	67	-	-	70	150	320	680	1380
	Breck Street to Laurel Lane	68	-	-	80	170	370	790	1570
	Laurel Lane to Orcutt Road	62	-	-	-	70	150	320	680
Higuera Street	Santa Rosa to Chorro Street	65	-	-	-	110	230	500	1070
	Chorro Street to Nipomo Street	65	-	-	-	110	230	500	1070
	Nipomo Street to Marsh Street	62	-	-	-	70	150	320	600
	Marsh Street to High Street	64	-	-	-	90	200	430	920

TABLE B-1. (Continued)

Route	Segment	Ldn Noise Level, dBA, at 50 feet	Distances to Ldn Noise Levels (from ℄, in feet)						
			75	70	65	60	55	50	45
	High Street to Madonna Road	68	-	-	80	170	370	790	1570
	Madonna Road to Elks Lane	65	-	-	-	110	230	500	1070
	Elks Lane to Prado Road	61	-	-	-	60	130	270	580
	Prado Road to Los Osos Valley Road	57	-	-	-	-	70	150	320
Foothill Blvd.	City Limits to Tassajara Drive	64	-	-	-	90	200	430	920
	Tassajara Drive to Santa Rosa Street	71	-	60	130	270	580	1210	2190
	Santa Rosa Street to Crandall Drive	63	-	-	-	80	170	370	790
Tank Farm Road	South Higuera St. to Edna Road	62	-	-	-	70	150	320	680
Los Osos Road	City Limits to Royal Way	65	-	-	-	80	100	220	600
	Royal Way to Madonna Road	73	-	80	170	370	790	1570	2600

TABLE B-1. (Continued)

Route	Segment	L_{dn} Noise Level, dBA, at 50 feet	Distances to L_{dn} Noise Levels (from ℄, in feet)						
			75	70	65	60	55	50	45
	Madonna Road to US 101	62	-	-	-	70	150	320	680
Madonna Road	Higuera Street to US 101	73	-	80	170	370	790	1570	2610
	US 101 to Oceanaire Drive	73	-	80	170	370	790	1570	2610
	Oceanaire Drive to Los Osos Valley Rd.	72	-	70	150	320	680	1380	2400
Mill Street	Chorro Street to Johnson Avenue	61	-	-	-	60	130	270	580
	Johnson Avenue to SPRR	60	-	-	-	-	110	230	500
	SPRR to Grand Avenue	59	-	-	-	-	90	200	430
Monterey Street	Santa Rosa Street to Johnson Avenue	64	-	-	-	90	200	430	920
	Johnson Avenue to Grand Avenue	66	-	-	60	130	270	580	1210
	Grand Avenue to US 101	63	-	-	-	80	170	370	790
Chorro Street	Highland Drive to Foothill Blvd.	65	-	-	-	110	230	500	1070

TABLE B-1. (Continued)

Route	Segment	Ldn Noise Level, dBA, at 50 feet	Distances to Ldn Noise Levels (from ℄, in feet)						
			75	70	65	60	55	50	45
	Foothill Blvd. to US 101	67	-	-	70	150	320	680	1380
	US 101 to Marsh Street	67	-	-	70	150	320	680	1380
	Marsh Street to Broad Street	61	-	-	-	60	130	270	580
Broad Street	Higuera Street to Chorro Street	62	-	-	-	70	150	320	680
	Chorro Street to Lawrence Drive	66	-	-	60	130	270	580	1210
	Lawrence Drive to Tank Farm Road	65	-	-	-	110	230	500	1070
	Tank Farm Road to Buckley Road	62	-	-	-	70	150	320	680
Patricia Drive	Foothill Blvd. to Westmont Drive	61	-	-	-	60	130	270	580
Grand Avenue	Monterey Street to Slack Street	61	-	-	-	60	130	270	580
Osos Street	US 101 to Islay Street	63	-	-	-	80	170	370	790

TABLE B-1. (Continued)

Route	Segment	Ldn Noise Level, dBA, at 50 feet	Distances to Ldn Noise Levels (from ℄, in feet)						
			75	70	65	60	55	50	45
Santa Barbara Street	US 101 to Islay Street	65	-	-	-	110	230	500	1070
Marsh Street	US 101 to Higuera Street	60	-	-	-	-	110	230	500
	Higuera Street to Broad Street	61	-	-	-	60	130	270	580
	Broad Street to Santa Rosa Street	64	-	-	-	90	200	430	920
	Santa Rosa Street to Johnson Avenue	63	-	-	-	80	170	370	790
	Johnson Avenue to California Blvd.	62	-	-	-	70	150	320	680
California Street	Foothill Blvd. to Hathway Avenue	63	-	-	-	80	170	370	790
	Hathaway Avenue to US 101	66	-	-	60	130	270	580	1210
	US 101 to Johnson Avenue	64	-	-	-	90	200	430	920
Pismo Street	Higuera Street to Osos Street	60	-	-	-	-	110	230	500

TABLE B-1. (Continued)

Route	Segment	L_{dn} Noise Level, dBA, at 50 feet	Distances to L_{dn} Noise Levels (from ℄, in feet)						
			75	70	65	60	55	50	45
	Osos Street to Johnson Avenue	64	-	-	-	90	200	430	920
Laurel Lane	Orcutt Road to Southwood Drive	66	-	-	60	130	270	580	1210
	Southwood Drive to Johnson Avenue	64	-	-	-	90	210	430	920
Orcutt Road	Broad Street to Laurel Lane	63	-	-	-	80	170	370	790
	Laurel Lane to Johnson Avenue	58	-	-	-	-	80	170	370
Santa Rosa Street	Foothill Blvd. to Murray Street	69	-	-	90	200	430	920	1770
	Murray Street to US 101	70	-	-	110	230	500	1070	2000
	US 101 to Monterey Street	69	-	-	90	200	470	920	1770
	Monterey Street to Marsh Street	67	-	-	70	150	320	680	1380
	Marsh Street to Railroad Station	64	-	-	-	90	200	430	920
Highway 1	City Limits	66	-	-	60	130	270	580	1210

APPENDIX B

Table B-1

Route	Segment	L_{dn} Noise Level, dBA, at 50 feet	Distances to L_{dn} Noise Levels (from Centerline, in feet)							
			75	70	65	60	55	50	45	
US 101	South City Limits to Madonna Road	76	60	130	270	580	1210	2190	3330	
	Madonna Road to Marsh Street	78	80	100	150	300	800	1300	2100	
	Marsh Street to Nipomo Street	78	80	100	150	390	800	1300	2100	
	Nipomo Street to Broad Street	78	70	100	150	390	800	1300	2100	West
			80	170	370	790	1570	2610	3860	East
	Broad Street to Chorro Street Overpass	78	80	170	370	790	1570	2610	3860	
	Chorro Street Overpass	78	80	170	370	790	1570	2610	3860	
	Chorro Street Overpass to Santa Rosa St.	78	80	170	370	790	1570	2610	3860	
	Santa Rosa St. to California Boulevard	76	60	90	120	300	650	1150	1700	
	California St. to Turner Ave.	73	-	70	100	150	390	800	1300	
	Turner Ave. to Grand Ave. Overpass	73	-	80	170	370	790	1570	2610	

APPENDIX B

Table B-1

Route	Segment	L_{dn} Noise Level, dBA, at 50 feet	Distances to L_{dn} Noise Levels (from Centerline, in feet)							
			75	70	65	60	55	50	45	
US 101	Grand Avenue Overpass	73	-	80	170	370	790	1570	2610	
	Grand Avenue Overpass to Buena Vista Ave. Underpass	74	-	90	200	430	920	1770	2840	
	Buena Vista Ave. Underpass	74	-	80	120	190	400	820	1350	
	Buena Vista Ave. Underpass to Monterey St.	74	-	90	200	430	920	1770	2840	
	Monterey Street to North City Limits	74	-	80	120	190	400	820	1350	North
			-	90	200	430	920	1770	2890	South

TABLE B-2. Distances to L_{dn} Noise Levels, Rail Traffic Noise

Route	Segment	L_{dn} Noise Level, dBA, at 100'	Distances to L_{dn} Noise Levels (from ℄, in feet)					
			70	65	60	55	50	45
SPTC Coast Route	North City Limits to Pismo St.	71	120	250	520	1050	2000	3500
	Pismo Street to Orcutt Road	70	100	240	510	1000	1800	3100
	Orcutt Road to South City Limits	71	120	250	520	1050	2000	3500
	Yard Barrier	70	100	200	310	430	880	1750
	Orcutt Knob Barrier	71	50	150	300	750	1520	3200